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10 MHz Dual-beam oscilloscope with delay line

PILLAR R.I.L CAN Keep R.W.N.

PM 3233

(9444 032 33...)

9499 440 13211 731101/01/02/03

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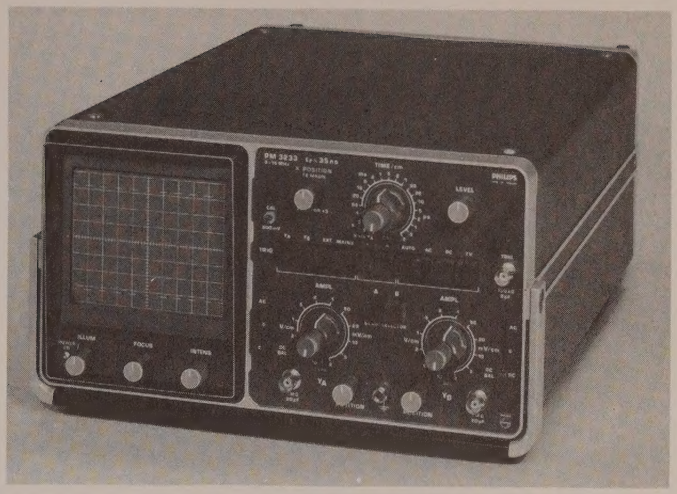

Instruction manual

10 MHZ Dual-beam oscilloscope with delay line PM3233

(9444 032 33...)

9499 440 13211

731101/01/02/03

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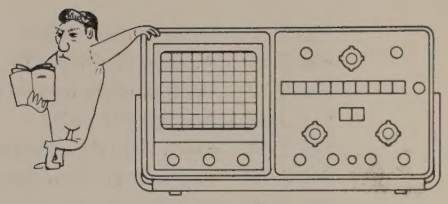
1. General information



1.1. Introduction

The 10 MHz Dual-beam Oscilloscope PM 3233 has been designed for general laboratory, service and educational applications.
Both vertical amplifiers are equipped with a drift-reduction circuit and a fully protected field-effect transistor input. All circuits are entirely transistorized and the transistors have been mounted on supports to enable quick servicing.
The instrument features a fully automatic facility which enables triggering on the line and frame sync pulses of a television signal.
The oscilloscope can be supplied from either a.c. mains or external d.c. sources.
The PM 3233 is equipped with a delay unit which provides signal delay to both channels Y_A and Y_B.

Fig. 1.1. Dual-beam oscilloscope PM 3233

1.2. Characteristics

Properties expressed in numerical values with stated tolerance are guaranteed for nominal mains voltages. Numerical values without tolerances are typical values representing the characteristics of an average instrument.

DESIGNATION	*SPECIFICATION*	*ADDITIONAL INFORMATION*
1.2.1. C.R.T.		
Type	PHILIPS E14-100	Split-beam tube, mesh type, post-accelerator, metal-backed phosphor
Measuring area	80 mm x 100 mm	
Screen type	P31 (GH) phosphor	For P7(GM) phosphor, order PM 3232G (ordering number E14-100GM tube in the parts list)
Total acceleration voltage	10 kV	
Overlap of the two systems	100 %	Both in horizontal and vertical direction
Graticule	External, removable	Continuously variable illumination
Engravings	Centimetre divisions with sub-divisions of 2 mm along the central axes. Broken lines indicate 10 % and 90 % of measuring lattice.	Area 80 mm x 100 mm
1.2.2. VERTICAL AMPLIFIERS		
1.2.2.1. Response		
Frequency range	d.c. ... 10 MHz 2 Hz ... 10 MHz	–3 dB bandwidth d.c. coupled –3 dB bandwidth a.c. coupled
Rise time	35 ns	
Overshoot	2 % at maximum	Test pulse of 1 ns rise time for 6 cm deflection at 1 MHz
1.2.2.2. Deflection coefficients	2 mV/cm ... 10 V/cm	Twelve calibrated positions in 1-2-5-sequence. Uncalibrated continuous control 1 : $\geqslant$ 2,5
1.2.2.3. Error limit	±3 % ±5 %	In range +5 °C ... +40 °C In range –10 °C ... +55 °C
1.2.2.4. Maximum permissible input voltage	±400 V	d.c. + a.c. peak
1.2.2.5. Instability of the spot position		
Long-term drift = short-term drift	0,25 cm/hour	Typical value
1.2.2.6. Vertical positioning	16 cm	

DESIGNATION	*SPECIFICATION*	*ADDITIONAL INFORMATION*
1.2.2.7. **Dynamic range**	24 cm	Peak-to-peak amplitude for sine-wave signals; at 3 MHz negligible distortion
1.2.2.8. **Input impedance**	1 MOhm//20 pF	
1.2.2.9. **Input RC time**	0,1 s	Coupling switch to A.C.
1.2.2.10. **Visible signal delay**	$\geqslant$ 40 nsec	Difference between the channels 0,1 division
1.2.3. **X-Y MODE**	X via Y_A	x5 magnifier inoperative
Horizontal frequency range	d.c. ... 1 MHz 2 Hz ... 1 MHz	
Phase shift	5^o 1^o	At 100 kHz At 10 kHz
Additional error for Y_A channel	±2 % ±3 %	In range +5 °C ... +40 °C In range −10 °C ... +55 °C
1.2.4. **TIME BASE**		
1.2.4.1. **Time coefficients**	0,5 s/cm ... 0,2 µs/cm	Twenty calibrated positions in 1-2-5 sequence. Uncalibrated continuous control 1 : $\geqslant$ 2,5
1.2.4.2. **Coefficient error**	±5 %	In range −10 °C ... +55 °C
1.2.4.3. **Expansion**		
Magnification	5x	Switched, calibrated
Additional error	±2 % ±3 %	In range +5 °C ... +40 °C In range −10 °C ... +55 °C
1.2.4.4. **Time-base output signal**		
Output voltage	300 mV	With 50 Ohm termination
Emf (open output voltage)	6 V_{p-p} (−2 V to +4 V)	The output terminal may be short-circuited without affecting the time coefficients
Internal resistance	1 kOhm	
1.2.4.5. **Positioning range**	The beginning and the end of the time-base line can be made visible	
1.2.5. **TRIGGERING**		
1.2.5.1. **Source**	Internal: channel Y_A, channel Y_B or mains freq. External	
1.2.5.2. **Trigger sensitivity**	Internal $\leqslant$ 1 cm at 10 MHz External $\leqslant$ 1 V_{p-p} at 10 MHz	For sine-wave signals

DESIGNATION	*SPECIFICATION*	*ADDITIONAL INFORMATION*
1.2.5.3. Input impedance	100 kOhm//5 pF	
1.2.5.4. Maximum permissible input voltage	±400 V	d.c. + a.c. peak
1.2.5.5. Trigger mode	Automatic or normal	
1.2.5.6. Level range	Corresponding to trace height 24 cm 24 V	In the automatic mode In the normal mode External
1.2.5.7. Triggering frequency range	10 Hz ... 10 MHz d.c. ... 10 MHz 20 Hz ... 10 MHz	A.C. coupling D.C. coupling A.C. coupling in the automatic mode
1.2.5.8. Triggering slope	+ or –	
1.2.5.9. Triggering with T.V. signals		Fully automatic; level control switched off.
Mode	Frame	Coupled with positions 50 µs/cm ... 0,5 s/cm
	Line	Coupled with positions 0,2 µs/cm ... 20 µs/cm
Trigger sensitivity	1 cm sync pulse	
1.2.6. INTENSITY MODULATION		A.C. coupled
Blanking voltage	⩾ +20 V	
Input resistance	⩾ 47 kOhm	
Frequency range	20 Hz ... 1 kHz	
Maximum permissible input voltage	±400 V	d.c. +a.c. peak
1.2.7. CALIBRATION GENERATOR		
Type	Square-wave generator	
Output voltage	600 mV_{p-p}	
Accuracy	±1 %	In range +5 °C ... +40 °C
Frequency	approx. 2 kHz	
1.2.8. OPERATING CONDITIONS		
1.2.8.1. Supply	a.c. or d.c.	
Nominal voltage range (on mains voltage adaptor)	a.c. 100 V ... 140 V 198 V ... 265 V d.c. 22 V ... 30 V	
Nominal frequency range	46 Hz ... 400 Hz	

DESIGNATION	*SPECIFICATION*	*ADDITIONAL INFORMATION*
1.2.8.2. Ambient temperature		
Rated range of use	+ 5 °C ... +40 °C	
Limit range of operation	−10 °C ... +55 °C	
Storage and transport conditions	−40 °C ... +70 °C	
1.2.8.3. Operating position	Any	
1.2.9. WARM-UP TIME	5 minutes	At constant ambient conditions (not including recovery time; see also section 2.4.5.)
1.2.10. POWER CONSUMPTION	40 VA at 220 V a.c. 20 W at 24 V d.c.	 0,85 A current drain
1.2.11. MAINS INTERFERENCE	The instrument meets the VDE Störgrad K requirement	
1.2.12. MECHANICAL DATA		
Design	Portable	
Dimensions	Depth 503 mm Width 326 mm Height 185 mm	Incl. front cover Incl. handle Incl. feet
Weight	Approx. 9,5 kg	
1.2.13. COOLING	Natural convection	
1.2.14. COMPONENT REPLACEMENTS	Normal production types, transistors plugged in	

1.3. Accessories

1.3.1. STANDARD ACCESSORIES

1 Front cover with storage space for two passive probes and two BNC-4 mm adapters
2 BNC-4 mm adapters PM 9051
1 Manual

1.3.2. OPTIONAL ACCESSORIES

Passive probe sets (10 : 1)	: PM 9326 and PM 9327
Passive probe sets (10 : 1)	: PM 9336 and PM 9336L
Passive probe set (1 : 1)	: PM 9335
2 kV passive probe set (100 : 1)	PM 9358
Set of miniature probe clips	PM 9333
Multi-purpose oscilloscope camera	: PM 9380
Adapter (oscilloscope to camera)	: PM 9379

See also chapter 3.5. Information concerning accessories

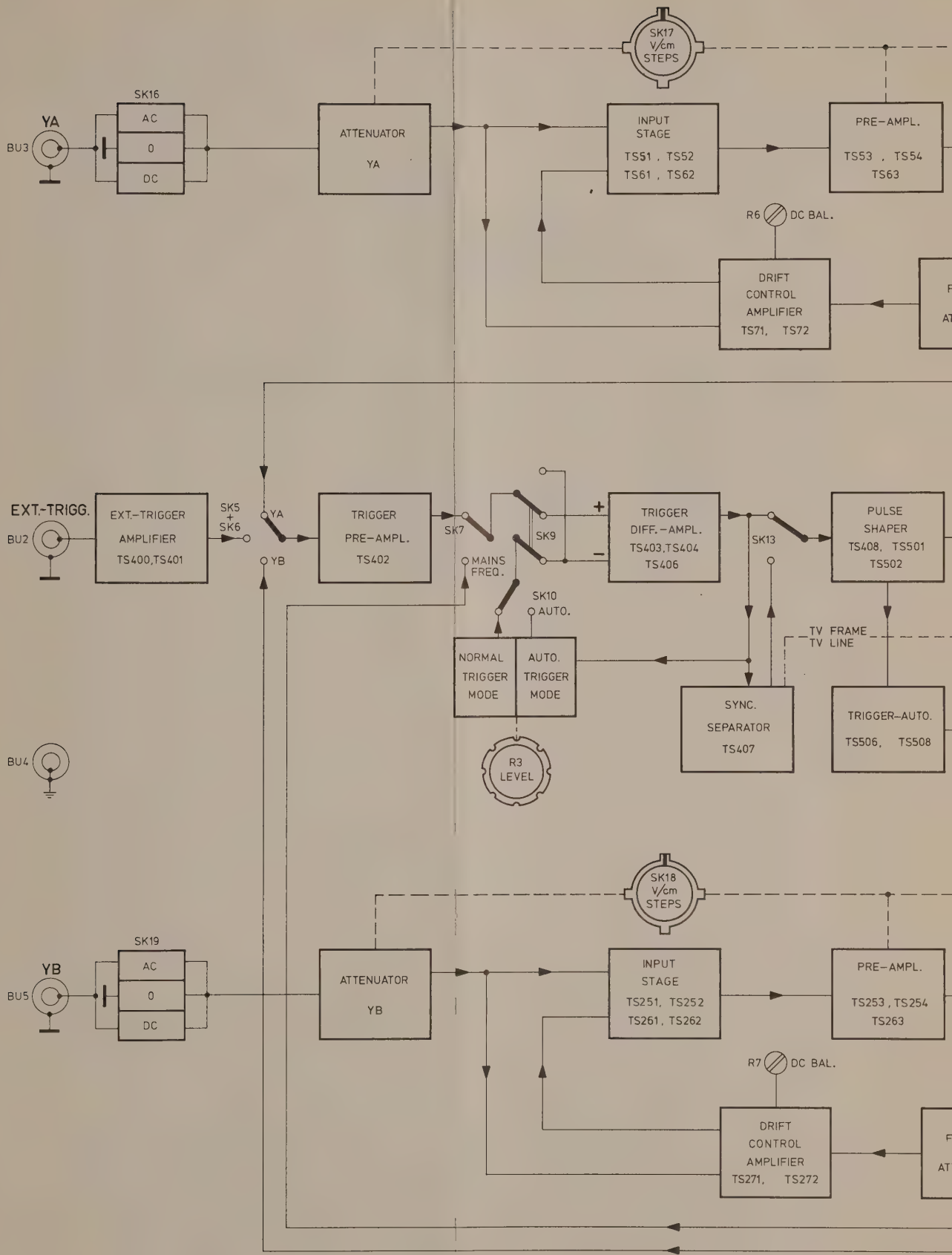
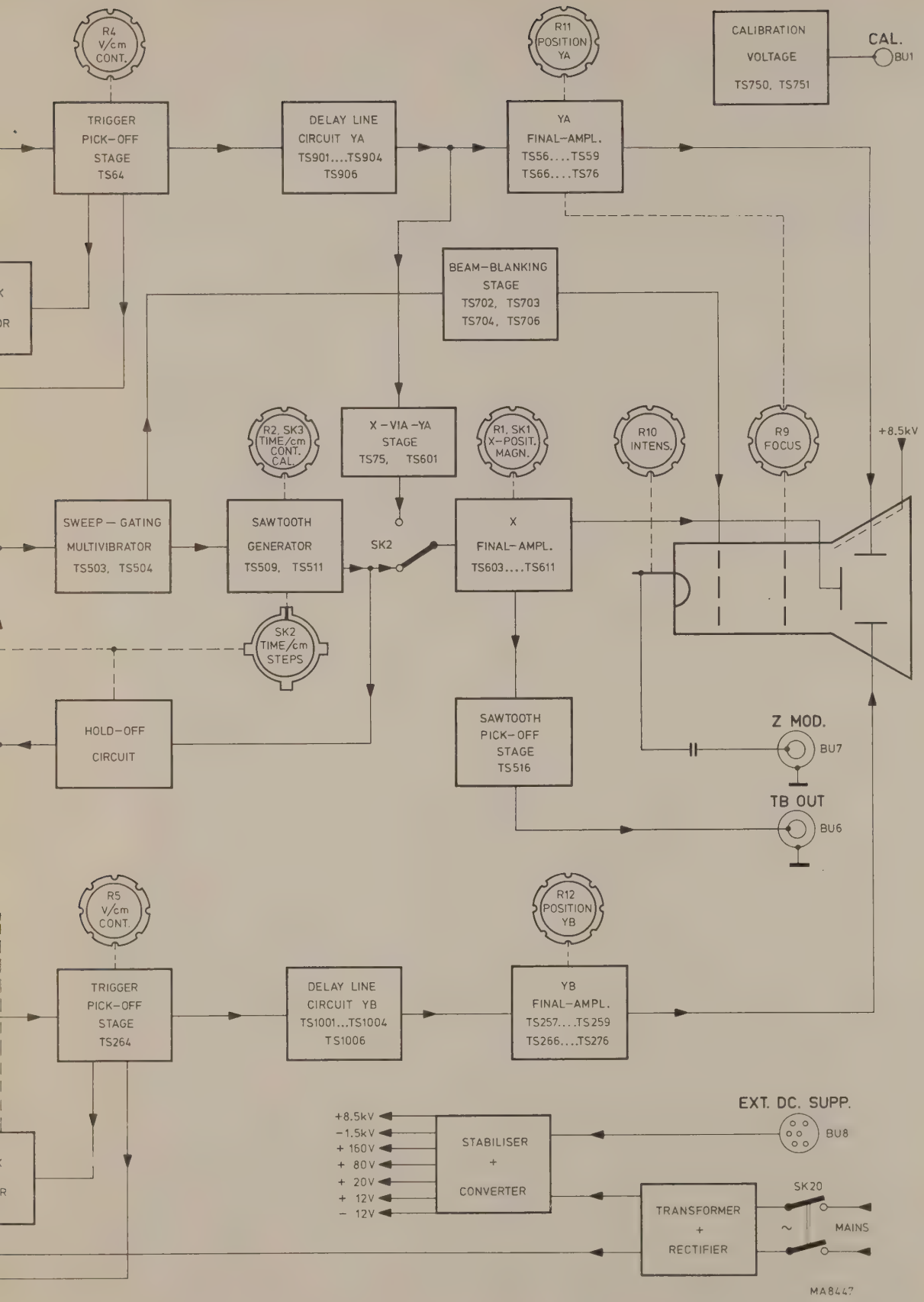


Fig. 1.2. Block diagram


R4 V/cm CONT.
R11 POSITION YA
CALIBRATION VOLTAGE TS750, TS751
CAL. BU1
TRIGGER PICK-OFF STAGE TS64
DELAY LINE CIRCUIT YA TS901....TS904 TS906
YA FINAL-AMPL. TS56....TS59 TS66....TS76
BEAM-BLANKING STAGE TS702, TS703 TS704, TS706
R2, SK3 TIME/cm CONT. CAL.
X-VIA-YA STAGE TS75, TS601
R1, SK1 X-POSIT. MAGN.
R10 INTENS.
R9 FOCUS
+8.5kV
SWEEP-GATING MULTIVIBRATOR TS503, TS504
SAWTOOTH GENERATOR TS509, TS511
SK2
X FINAL-AMPL. TS603....TS611
SK2 TIME/cm STEPS
HOLD-OFF CIRCUIT
SAWTOOTH PICK-OFF STAGE TS516
Z MOD. BU7
TB OUT BU6
R5 V/cm CONT.
R12 POSITION YB
TRIGGER PICK-OFF STAGE TS264
DELAY LINE CIRCUIT YB TS1001...TS1004 TS1006
YB FINAL-AMPL. TS257....TS259 TS266....TS276
EXT. DC. SUPP. BU8
+8.5kV
-1.5kV
+ 160V
+ 80V
+ 20V
+ 12V
- 12V
STABILISER + CONVERTER
TRANSFORMER + RECTIFIER
SK20
MAINS
MA8447

1.4. Description of the block diagram

1.4.1. Y AXIS

The oscilloscope PM 3233 has two identical, d.c. coupled vertical amplifiers allowing simultaneous display of two signals. Each amplifier comprises an input step-attenuator, a source follower with protection circuitry, a pre-amplifier and a drift reduction circuit, a trigger pick-off stage, a delay line circuit and a final amplifier. Trigger pick-off stage and final amplifier (for both channels, Y_A and Y_B) have been coupled by means of the delay line circuit, which is a part of the circuitry of the delay line unit.
The protection circuitry prevents damage to the input field-effect transistors by too high an input voltage. The drift-reduction circuit reduces the drift inherent in the high sensitivity of the amplifier.

The trigger pick-off stage supplies a triggering signal to the trigger pre-amplifier in case of internal triggering, and also couples the signal to the Y final amplifier. In the Y_A channel the signal can also be coupled to the X final amplifier if the instrument is used as an XY oscilloscope. From the Y final amplifier, the signal is fed to the Y deflection plates of the c.r.t.

The delay line has been applied to enable the display of the leading edge of fast phenomena on the screen.

1.4.2. TRIGGERING

A triggering signal can be obtained from either vertical amplifier, from an external source or internally from the mains. The latter signal is not available when the instrument is supplied with an external d.c. voltage. The triggering signal is fed to a trigger pulse shaper which supplies well-defined trigger pulses to start the time-base generator. The trigger unit also comprises a sync separator for television signals so that triggering by means of these signals is also possible.

1.4.3. TIME BASE

The time-base generator is of the constant-current integrator type and supplies two output voltages.
A sawtooth voltage which is fed to the X final amplifier and an output socket at the rear of the oscilloscope and a gate pulse which controls the unblanking of the c.r.t. during the sweep.

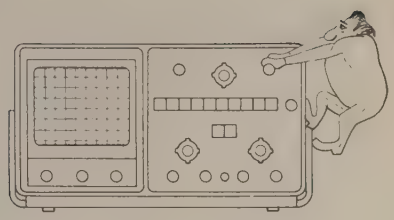
1.4.4. X AXIS

The X final amplifier receives its input signal from either the time-base generator or from an external source via the Y_A channel. From the X amplifier the signal is fed to the horizontal deflection plates of the c.r.t. of the oscilloscope.

1.4.5. CATHODE-RAY TUBE CIRCUIT

The cathode-ray tube is of the split-beam type with one control for the brilliance of the trace and one for focusing. The cathode of the c.r.t. is a.c. coupled to a socket for external Z modulation.
The high voltages for the c.r.t. are generated by a converter which also delivers the other supply voltages.

2. Directions for use



2.1. Installation

2.1.1. REMOVING AND FITTING THE FRONT COVER

Removing: – Turn the knob in the centre of the cover a quarter of a turn anti-clockwise.
– Take the cover off.

Fitting: – Align the key of the locking knob with the slot in the text plate of the instrument.
– Fit the cover over the front of the oscilloscope.
– Press the knob and turn it a quarter of a turn clockwise.

WARNING

This instrument generates high voltages and should not be operated with the covers removed. The mains plug or external voltage source should be removed before attempting any maintenance work, and any relevant high voltage points discharged.

2.1.2. ADJUSTING TO THE LOCAL MAINS SUPPLY AND FUSES

Before switching-on, the instrument must be adjusted to the local mains voltage by means of the voltage adapter at the rear.
It is possible to adjust the instrument to 110 V, 127 V, 220 V and 240 V by means of a screwdriver.
The selected voltage is visible through the opening at the rear.
The instrument can optionnaly (Spec. V) be adapted for 100 V, 127 V, 200 V and 220 V.
The temperature-sensitive fuse is mounted between the mains transformer windings. It can be replaced after having removed the rear cover (3 screws "X", Fig. 2-1).
Terminals "N" and "1" (see transformer at Fig. 3.20 and Fig. 3.43) must be unsoldered; in order to remove the fuse, bend the enclosure slightly to the outside so that the locking pin can be disengaged.
A new fuse is removed from its housing in the same way as described before. It is then pushed in the same enclosure as the old one until the locking pin snaps into the hole, the loop pointing to the "N" terminal.
After having terminals "N" and "1" soldered, the instrument can be considered as ready for use.

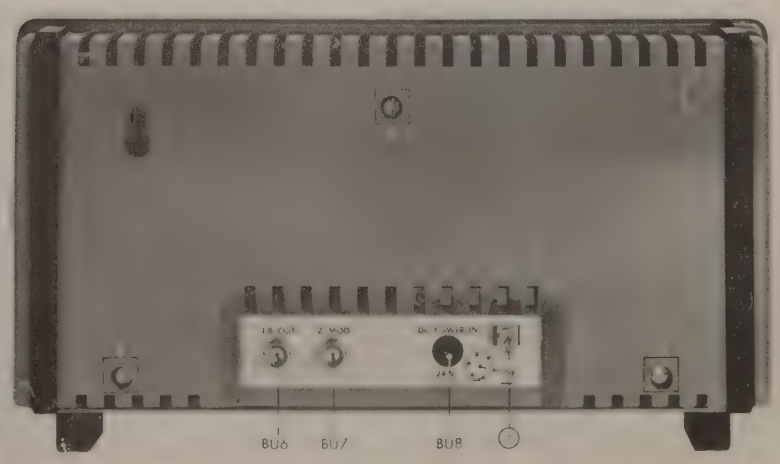


Fig. 2.1. Rear view showing sockets

2.1.3. SUPPLY FROM AN EXTERNAL D.C. SOURCE

The instrument may be supplied from an external d.c. source of 22 V to 30 V, 0,85 A. This voltage is to be applied to EXT. D.C. SUPPLY socket BU8. THE POSITIVE TERMINAL OF THE VOLTAGE SOURCE MUST BE CONNECTED TO EARTH, AS INDICATED IN THE DIAGRAM ON THE REAR TEXT PLATE, SINCE THE POSITIVE SIDE OF THE POWER SUPPLY IS CONNECTED TO CHASSIS.
The instrument is protected against reverse connection. In the case of external d.c. supply, the instrument is protected by fuse VL802 (Fig. 2.2.) which is located on the power supply board and accessible after removing the rear cover. VL802 is a delayed action, 1,25 A fuse.

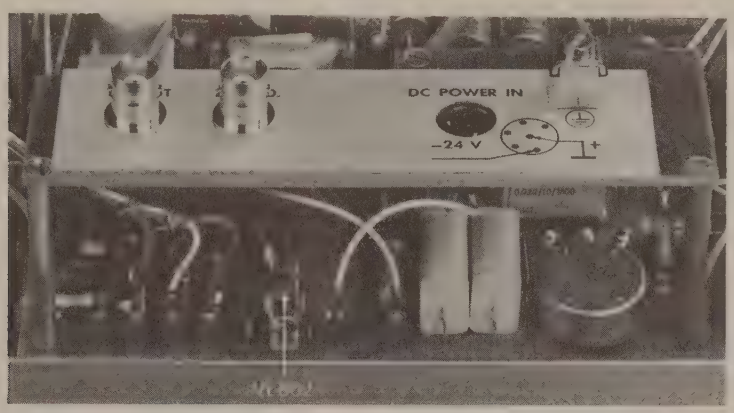


Fig. 2.2. Rear view showing fuse VL802

2.1.4. EARTHING

In the interests of safety, the oscilloscope must be connected to earth via the rear earthing terminal (identified by the symbol ⏚) or via the mains lead, provided that the supply socket is equipped with an earth connection. Care must be taken that the earth line to the oscilloscope is not interrupted due to the use of an extension lead or device which is not fitted with an earth conductor.

2.1.5. SWITCHING ON

The instrument is switched on in case of mains supply, by means of the mains switch incorporated in the ILLUM. control. The mains cable is located in a compartment at the bottom of the instrument.

In case of external d.c. supply, the mains switch is inoperative and the instrument is on as soon as the external source is connected. In both cases, the ON position is indicated by the white pilot lamp.

The instrument may be used in any position, but care should be taken that a free air circulation is not impeded. For temperature conditions refer to section 1.2.8.2.

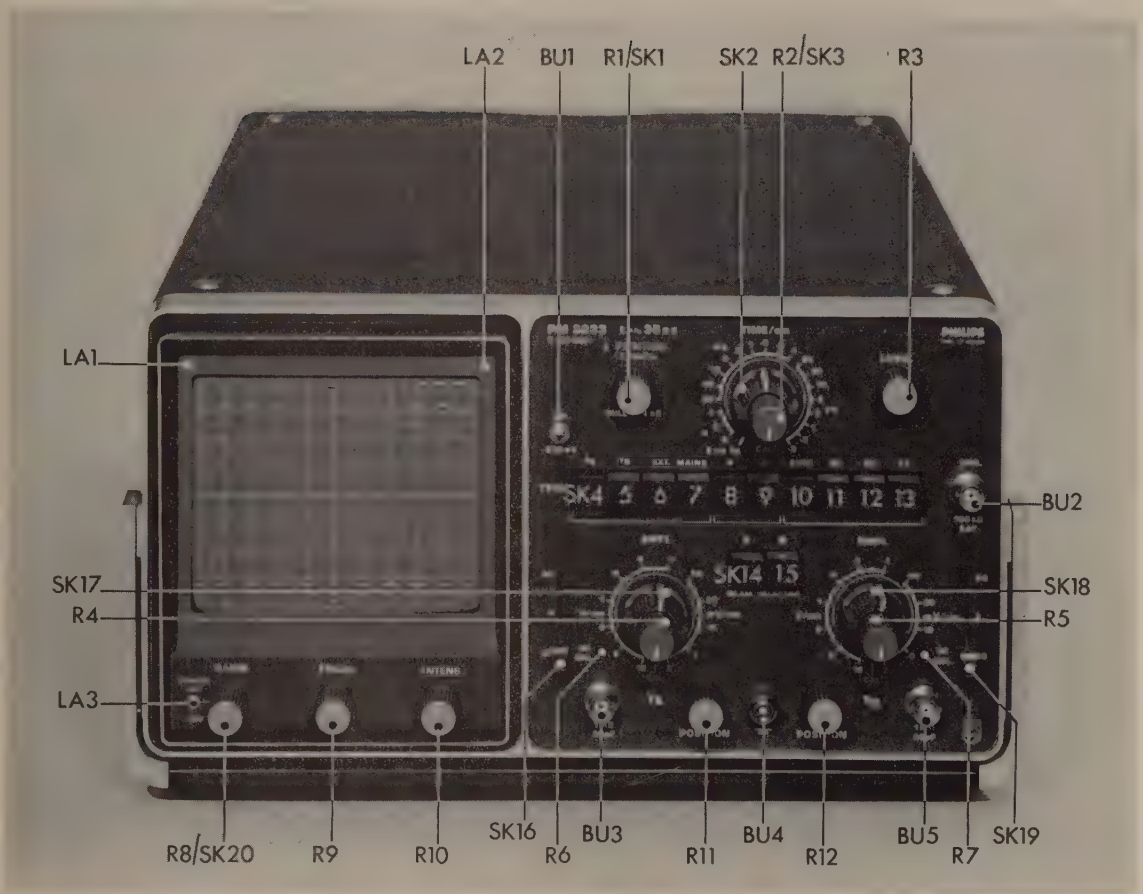


Fig. 2.3. Front view showing controls and sockets

2.2. Operating instructions

Before switching on, ensure that the oscilloscope has been correctly installed in accordance with chapter 2.1. Installation, and that the precautions outlined have been observed.

2.2.1. CONTROLS AND SOCKETS (Fig. 2.3.)

X POSITION (R1) MAGN. (SK1)	Continuously variable control giving horizontal positioning of the display. Incorporates a switch for calibrated 5x magnification of the time base.
TIME/cm (SK2)	Time-coefficient control of the time-base; 21-way switch with a position for external X deflection (X via Y_A).
CAL. - TIME/cm (R2/SK3)	Continuously variable control of the time coefficients. In the CAL. position the time-coefficient is calibrated.
LEVEL (R3)	Continuously variable control to select the level at which the time-base generator starts.
CAL. (BU1)	Outlet for square-wave voltage of 600 mV_{p-p} for calibration purposes.
TRIGGERING (SK4...13)	Controls for trigger source, slope and mode; 10-way push-button switch.
Y_A (SK4)	Internal triggering signal derived from channel Y_A.
Y_B (SK5)	Internal triggering signal derived from channel Y_B.
EXT. (SK6)	Triggering signal derived from a voltage applied to the TRIGG. input socket.
MAINS (SK7)	Triggering signal derived from an internal voltage with the mains frequency. This trigger source is inoperative when the instrument is supplied with an external d.c. voltage.
+ (SK8)	Provides for triggering on the positive slope of the signal.
– (SK9)	Provides for triggering on the negative slope of the signal.
AUTO (SK10)	Provides for a free-running time-base in the absence of triggering signals and automatic signal-derived limitation of the LEVEL control range.
AC (SK11)	Triggering with coupling capacitor in triggering-signal path.
DC (SK12)	Direct coupling for triggering on a slowly varying voltage, or for full-bandwidth working.
TV (SK13)	Enables triggering on either line or frame pulses of TV signals, as dictated by the position of TIME/cm switch SK2. Triggering on frame pulses in positions 50 μs/cm to 0,5 s/cm and on line pulses in position 0,2 μs/cm to 20 μs/cm.
TRIGG. (BU2)	Input BNC socket for external triggering signals.
BEAM SELECTOR A (SK14)	If this push-button is depressed, vertical deflection is achieved by the signal connected to the channel Y_A input.

BEAM SELECTOR B (SK15)	If this push-button is depressed, vertical deflection is achieved by the signal connected to the channel Y_B input. If both switch A (SK14) and switch B (SK15) are depressed, vertical deflection is achieved by both the signal connected to the channel Y_A input and the signal connected to the channel Y_B input.
AC-0-DC (SK16 & 19)	Signal coupling, three position switch. AC : via a coupling capacitor 0 : interruption of connection between input socket and input circuit, the latter being earthed. DC : Direct coupling.
AMPL. (SK17 & 18)	Control of the vertical deflection coefficients, 12-way switch.
CAL. - AMPL. (R4 & 5)	Continuously variable control of the vertical deflection coefficients. In the CAL. position, the deflection coefficient is calibrated.
DC BAL. (R6 & 7)	Continuously variable control of the direct-voltage balance of the vertical amplifier.
ILLUM. (SK20 & R8)	Continuously variable control of the graticule illumination. Incorporates mains switch.
FOCUS (R9)	Continuously variable control of the electron-beam focusing.
INTENS. (R10)	Continuously variable control of the trace brilliance.
1 MOhm - 20 pF (BU3 & 5)	Input BNC socket for the vertical deflection signals.
POSITION (R11 & 12)	Continuously variable control giving vertical positioning of the display.
⏚ (BU4)	Earth socket.
At the rear of the instrument (Fig. 2.1.):	
TB OUT (BU6)	Sawtooth output BNC socket
Z MOD. (BU7)	Input BNC socket for intensity-modulation voltages.
EXT. DC SUPPLY (BU8)	Input socket for d.c. supply.

2.2.2. PRELIMINARY SETTINGS

We recommend to allow a warm-up time of five minutes before you start your measurements. This warm-up time does not include a recovery time when the instrument comes in from the cold (see also section 2.4.5.).

- In case of mains operation:
  Check that the mains voltage adapter indicates the local mains voltage. If necessary, set the adapter to the relevant voltage in accordance with section 2.1.2.
  Switch on the instrument.
- In case of external d.c. supply:
  Check that the external source is properly connected, with the positive terminal to earth.
- Set FOCUS control R9 and INTENS. control R10 to their mid-positions.
- Depress BEAM SELECTOR buttons A SK14 and B SK15. Bear in mind that their will be no display if no BEAM SELECTOR button is depressed.
- Select trigger source, slope and mode. If no TRIGG. button has been depressed, the oscilloscope triggers on the Y_A signal, on the positive slope and in an AUTO mode without level range limitation.
- Display the two traces by means of Y POSITION controls R11 and R12.

The oscilloscope is then ready for use. For correction of the d.c. balance, refer to section 3.2.4.2.

2.2.3. INPUTS Y_A AND Y_B AND THEIR POSSIBILITIES

The PM 3233 has been provided with two identical vertical channels which can be used for either YT measurements in combination with the time-base generator, or XY measurements up to frequencies of 1 MHz.

2.2.3.1. YT Measurements

To display one signal, either of the two vertical channels can be selected by operating either BEAM SELECTOR A SK14 or BEAM SELECTOR B SK15. When both push-buttons A SK14 and B SK15 are depressed, two signals can be displayed simultaneously. The Y deflection coefficient can be individually set for each channel.

2.2.3.2. XY Measurements

If TIME/cm switch SK2 is set to position X via Y_A, the time-base generator is switched off. The signal of the Y_A channel is displayed horizontally. The Y_A controls, except the POSITION potentiometer R11, then control the X deflection. Positioning of the trace in horizontal sense is still possible with X POSITION control R1. The x5 MAGNIFIER switch SK1, however, is inoperative.
In this mode, XY measurements can be up to a frequency of 100 kHz.

2.2.3.3. Influence of the AC-0-DC switch

Signals to be studied can be fed to Y_A input socket BU3 and/or to Y_B input socket BU5. Depending on the composition of the signal, the AC-0-DC switch should be set to position AC or DC. In position DC, the input is coupled direct to the Y amplifier. Because the Y amplifier is d.c. coupled, the entire bandwidth of the instrument is available. This means that the complete input voltages are fed to the deflection plates, which implies that the d.c. components result in trace shifts on the screen.
This may cause difficulties when a.c. signals superimposed on high direct voltages have to be displayed.
In order to make the a.c. signal visible in those cases, a greater attenuation will be necessary with the result that the a.c. signal will also be strongly attenuated.

In this case the AC-0-DC switch can be set to position AC. Then a blocking capacitor is connected between the input socket and the Y amplifier. As a result of this, d.c. voltages are blocked, but also the lower frequencies are suppressed or attenuated. When square-wave signals of low frequency are displayed, this will result in some pulse droop.
In the 0 position of the AC-0-DC switch it is possible to quickly determine the zero volt d.c. level.
In this position the connection between the amplifier input and the input socket is interrupted, the amplifier input being earthed. At the same time, the blocking capacitor is discharged to prevent damage of the circuit under test by a possible high charge.

2.2.4. TRIGGERING

2.2.4.1. General

In order to obtain a stationary trace, the horizontal deflection must always be started at a fixed point of the signal. The time-base generator is, therefore, started by narrow trigger pulses formed in the trigger pulse shaper (Schmitt-trigger), controlled by a signal originating from the vertical input signal or an external source.

2.2.4.2. Trigger coupling

AC — If the signal voltage contains a d.c. component triggering can cease when the level potentiometer cannot supply the correct d.c. level for the Schmitt trigger. In this case it is useful to apply a.c. coupling. A.C. Coupling is obtained by inserting a capacitor in the trigger path. This means that the signal can still be d.c. coupled to the Y channels.

DC — D.C. Coupling is useful when the mean value of the signal varies. This sort of signal often occurs in digital systems. With a.c. coupling the trigger point would not be fixed which would give rise to jitter or even loss of triggering.

2.2.4.3. Trigger level

In case of a complicated signal in which a number of non-identical voltage shapes occur periodically, the time axis should always be started with the same voltage shape so as to obtain a stationary trace.
This is possible when one of the details has a deviating amplitude. By means of the LEVEL knob, the trigger level can be set in such a way that only this larger voltage variation passes this level. The LEVEL control is also very useful when two signals must be accurately compared e.g. in phase measurements. By means of the LEVEL control the starting point of the traces can then be shifted exactly on to the control graticule line.

2.2.4.4. Automatic triggering

Automatic triggering, when the AUTO switch is depressed, is most often used on account of its simple operation. In this mode it is possible to display a large variety of waveforms having different amplitude and shape, without it being necessary to operate any of the trigger controls.
If no triggering signal is present, a time-base line remains visible on the screen. This is useful for zero reference purposes. In this trigger mode the level can be adjusted over the peak-to-peak value of the a.c. component of the signal. If none of the switches AUTO, AC, DC or TV is depressed, the oscilloscope works in the automatic mode, but with the entire level range available. This has the advantage that there is always a trace visible, even when no TRIGG. push-buttons are depressed.

2.2.4.5. External triggering

External triggering is applied for signals having a strongly varying amplitude, if a signal having a fixed amplitude and equal frequency is available. Even more important is external triggering in case of complex signals and pulse patterns. Then external triggering can be used to avoid double traces.
This obviates the necessity of readjusting the level setting at every variation of the input signal.

2.2.4.6. Triggering with the mains frequency

In this case the triggering signal is a sine-wave with the mains frequency. This trigger source is useful if the frequency of the signal under observation is coupled with the mains frequency.
It is, e.g., possible to recognize the hum component of a signal by triggering on that component.

2.2.4.7. Triggering with television signals

It is possible to trigger on the line or frame sync pulses of television signals. In positions .5 s to 50 μs of the TIME/cm switch triggering takes place on the frame sync pulses and in positions 20 μs to .2 μs on the line sync pulses of the signal.
The position of the trigger slope switches must correspond to the polarity of the video information of the signal.

2.2.5. TIME-BASE MAGNIFIER

The magnifier is operated with a push-pull switch.
When this switch is in the x5 position, the time-base sweep speed is increased 5 times. In this position the sweep time is determined by dividing the indicated TIME/cm value by 5.

2.2.6. Z MODULATION

In order to bring extra information in the c.r.t. display without changing the form of the display, the brightness of the trace can be lowered by an externally applied voltage. The external signal must, therefore, be fed to the Z MOD socket at the rear of the oscilloscope.
The voltage required for visible brightness modulation depends on the position of the INTENS control.
With an average brightness of the trace, a +20 $V_{p\text{-}p}$ voltage is amply sufficient for obtaining a good visible Z modulation.

2.3. Applications

In the following we describe the procedure and technique for basic measurements with a PM 3233 oscilloscope.

2.3.1. VOLTAGE MEASUREMENTS

Display the waveform as large as possible in order to obtain maximum accuracy. For all voltage measurements the AMPL. potentiometers must be in the CAL. position, otherwise the deflection coefficients are not calibrated.

When using a 10 : 1 attenuator probe, observe that the displayed amplitude must be multiplied by a factor 10. Ensure that the probe is adjusted for good step response, and, in the interest of accuracy, that the gain is checked with the aid of the CAL. voltage.

2.3.1.1. Peak-to-peak voltage measurements

To measure the peak-to-peak value of the a.c. component of a waveform, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the TIME/cm switch to display a few cycles of the waveform as illustrated in Fig. 2.4.
2. Adjust the Y POSITION control so that the lower peaks of the waveform coincide with the nearest horizontal graticule line.
3. Adjust the X POSITION control so that one of the upper peaks of the signal coincides with the central vertical graticule line.
4. Measure the vertical distance between the peaks of the signal.
5. Multiply the measured distance by the voltage setting of the AMPL. switch, and by the attenuation factor of the probe if any.

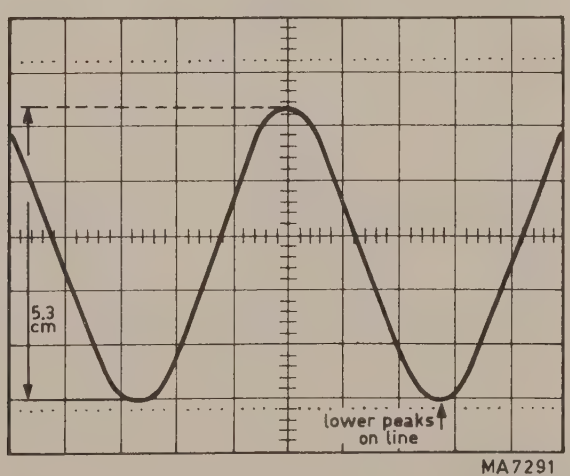


Fig. 2.4. Peak-to-peak voltage measurement

Example: Assume that the AMPL. switch is set to 2 mV/cm and a 10:1 attenuator is used. The measured vertical distance is 5,3 cm.

Using the formula: $V_{p\text{-}p}$ = (vertical distance) . (AMPL. setting) . (probe attenuation)
$= 5{,}3 \,.\, 2 \,.\, 10^{-3} \,.\, 10 = 106$ mV

If the waveform is purely sinusoidal, the r.m.s. voltage is:

$$V_{r.m.s.} = \frac{V_{p\text{-}p}}{2\sqrt{2}} = \frac{106 \,.\, 10^{-3}}{2\sqrt{2}} = 38{,}2 \text{ mV}$$

2.3.1.2. Instantaneous-voltage measurements

To measure the instantaneous voltage of a waveform, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible.
Then proceed as follows:

1. Set the Y input switch to 0 and adjust the Y POSITION control so that the zero reference line coincides with the nearest horizontal graticule line.
   THE Y POSITION CONTROL MUST NOT BE MOVED AFTER THIS REFERENCE LINE HAS BEEN ESTABLISHED.
2. Set the Y input switch to DC.
3. If desired, rotate the X POSITION control so that the point to be measured lies on the vertical centre line.
4. Measure the vertical distance between this point and the zero-reference line. If the point lies above the reference line, the voltage is positive; if the point lies below the line, the voltage is negative.
5. Multiply the measured distance by the voltage setting of the Y AMPL. switch an the attenuation factor of the probe if any.

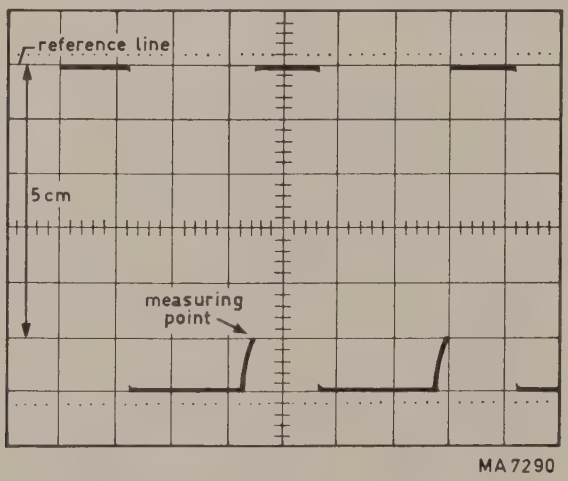


Fig. 2.5. Instantaneous-voltage measurement

Example: Assume that the Y AMPL. switch is set to .1 V/cm and that a 10:1 attenuator probe is used. The measured vertical distance is 5 cm (Fig. 2.5.).

Using the formula V_{inst} = (vertical distance) . (YAMPL setting) . (probe attenuation)
$= 5.10^{-1} \,.\, 10 = 5$ V, of negative polarity.

TO MEASURE A VOLTAGE LEVEL WITH RESPECT TO ANOTHER VOLTAGE RATHER THAN TO EARTH, APPLY THE REFERENCE VOLTAGE TO THE INPUT SOCKET.
ADJUST THE Y POSITION CONTROL, SO THAT THE TRACE COINCIDES WITH A HORIZONTAL GRATICULE LINE WHICH CAN NOW BE USED AS THE REFERENCE LINE.
THIS REPLACES THE ZERO-REFERENCE PROCEDURE DESCRIBED IN STEP 1.

2.3.2. TIME AND FREQUENCY MEASUREMENTS

For all time and frequency measurements, the TIME/cm potentiometer must be in the CAL. position, otherwise the sweep speeds are not calibrated.

2.3.2.1. Time measurements

To measure the time interval between two points of a waveform, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the TIME/cm switch so that the horizontal distance between the time-measuring points is as large as possible.
2. Rotate the X POSITION control so that one of the measuring points coincides with the nearest vertical graticule line.
3. Rotate the Y POSITION control to bring the other point to the horizontal centre line.
4. Measure the horizontal distance between the two time-measuring points.
5. Multiply the measured distance by the TIME/cm setting (if magnification is used, divide this product by 5).

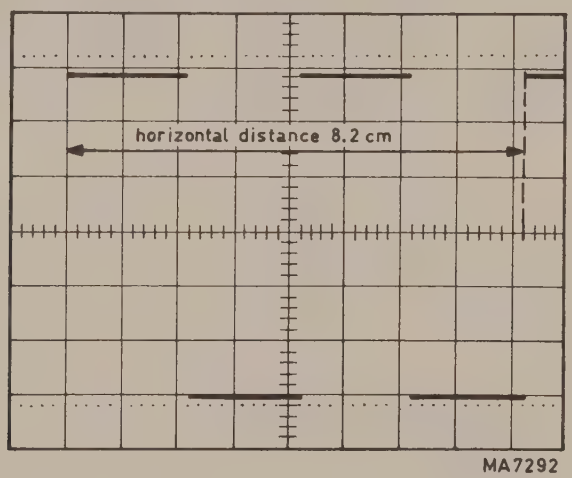


Fig. 2.6. Measuring a time interval

Example: Assume that the TIME/cm setting is .5 μs/cm and the magnifier is on. The measured distance is 8,2 cm (Fig. 2.6.).

Using the formula

$$\text{Time interval} = \frac{\text{horizontal distance . TIME/cm setting}}{\text{magnification}}$$

$$= \frac{8{,}2 \,.\, 5 \,.\, 10^{-7}}{5} = 0{,}82\ \mu\text{s}$$

After measuring the time duration of one cycle in the way described above, the frequency can easily be calculated:

$$\text{frequency} = \frac{1}{\text{time duration of one cycle}}$$

2.3.2.2. Rise-time measurements

Rise time t_r is defined as the time required by the leading edge of a signal to rise from 10 % to 90 % of the amplitude.
When the oscilloscope rise time is comparable with that of the signal under test, the actual rise time should be calculated as follows:

$$\text{actual } t_r = \sqrt{(\text{measured } t_r)^2 - (\text{oscilloscope } t_r)^2}$$

This calculation is not necessary when the signal rise-time is longer than 150 ns (the error is then 5 % and decreases rapidly when the rise-time becomes longer).

To measure the rise time of a signal, connect the signal to one of the Y input sockets and adjust the Y controls to display as large a trace as possible. Then proceed as follows:

1. Set the TIME/cm switch to display the total voltage step on the screen.
2. Adjust the Y amplitude so that the vertical deflection is exactly 8 cm. The 10 % and 90 % points now coincide with the dotted lines of the graticule.
3. Adjust the X POSITION control so that the 10 % point coincides with the nearest vertical graticule line; this line now is the reference line, and no further adjustment of the X POSITION control should be made.
4. Measure the horizontal distance between the time-reference line (coincident with the 10 % point) and the point of intersection of the signal and the horizontal 90 % line.
5. The rise-time is given by the product of the horizontal distance in cm and the TIME/cm setting. If magnification is used, this product must be divided by 5.

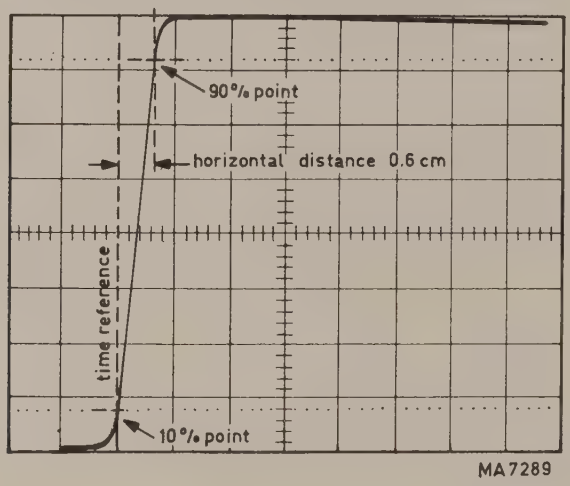


Fig. 2.7. Measuring the rise time of a signal

Example: Assume that the TIME/cm setting is .2 μs and magnification is not used. The oscilloscope rise time is 35 ns.
The measured distance is 0,6 cm (Fig. 2.7.).

Using the formula

$$\text{Measured rise-time} = \frac{\text{TIME/cm setting . horizontal distance}}{\text{magnification}}$$

$$= \frac{2 \cdot 10^{-7} \cdot 6 \cdot 10^{-1}}{1} = 120 \text{ ns}$$

Substituting in the formula:

$$\text{actual rise-time} = \sqrt{(\text{measured rise-time})^2 - (\text{oscilloscope rise-time})^2}$$

$$= \sqrt{14400 - 1225} = \sqrt{13175} \approx 115 \text{ ns}$$

When measuring fast rise times, it is useful to start the time-base generator by means of a pre-pulse applied to the external trigger input. The time relation between the pre-pulse and the signal under test should be such, that the complete leading edge of the signal under test is displayed.

2.3.3. PHASE MEASUREMENTS

To measure the phase difference between two sine-wave signals, use the following method.
Connect one signal to the Y_A input socket and the other to the Y_B input socket, using probes or coaxial cables of the same type and length, thus, WITH EQUAL TIME DELAYS. Display the traces using the AUTO mode of the time-base. With a stable display of maximum amplitude, adjust the Y POSITION controls for symmetry about the horizontal centre line, and adjust the LEVEL control in such a way that the starting point of the first signal lies on the horizontal centre line.
When you have set up the display, proceed as follows:

1. Set the TIME/cm switch and potentiometer to such positions that half a cycle of the first signal occupies exactly 9 cm horizontally; i.e. each cm represents $180^o/9 = 20^o$.
2. Measure the horizontal distance between the two corresponding points on the waveforms and multiply this by 20^o to obtain the phase difference.

For small phase differences (less than 45^o) use the x5 magnifier. The phase scale is then 4^o/cm.
Therefore, the measured distance in cm must be multiplied by 4^o to obtain the desired phase difference.

2.3.4. XY MEASUREMENTS

As examples of the use of the XY measurements we shall described methods to display a hysteresis loop and a diode characteristic.

2.3.4.1. Displaying a hysteresis loop (Figs. 2.8. & 2.9.)

In displaying hysteresis loops of magnetic material, the magnetic induction B is plotted as a function of field strength H. If the iron core of a coil contains no air gaps, the field strength is proportional to the current through the number of windings. The primary current is thus a measure of the field strength H. A resistor R_p is connected in series with the primary. The voltage across this resistor is applied to the Y_A input (TIME/cm switch in position X via Y_A).

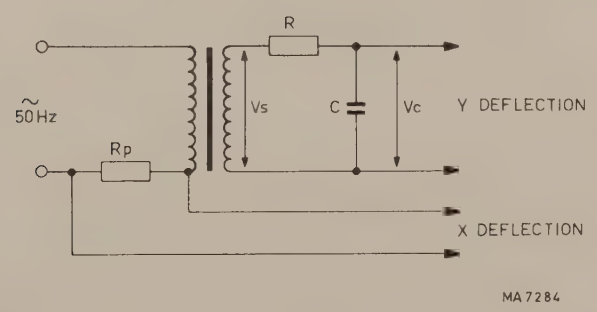


Fig. 2.8. Displaying a hysteresis loop, approximate method

The voltage across the secondary is $V_s = k \cdot \frac{dB}{dt}$, in which k is a constant. This voltage is integrated by an RC network ($R >> \frac{1}{\omega C}$). The voltage across the capacitor then becomes $V_c = \frac{kB}{RC}$.

The induction B is, thus, proportional to the voltage across the capacitor. This voltage is fed to the Y_B input. This method is an approximation, as it is not possible to have a phase difference of 90° between input and output voltage.

An exact method is shown in Fig. 2.9., but, for this, the transformer must have a filament supply winding with a centre tap or two separate filament supply winding with the same supply voltages.

In the latter case, the two windings must be connected in series, the connection point serving as a centre tap. The 90° phase difference can be obtained by adjusting the 100 kΩ potentiometer.

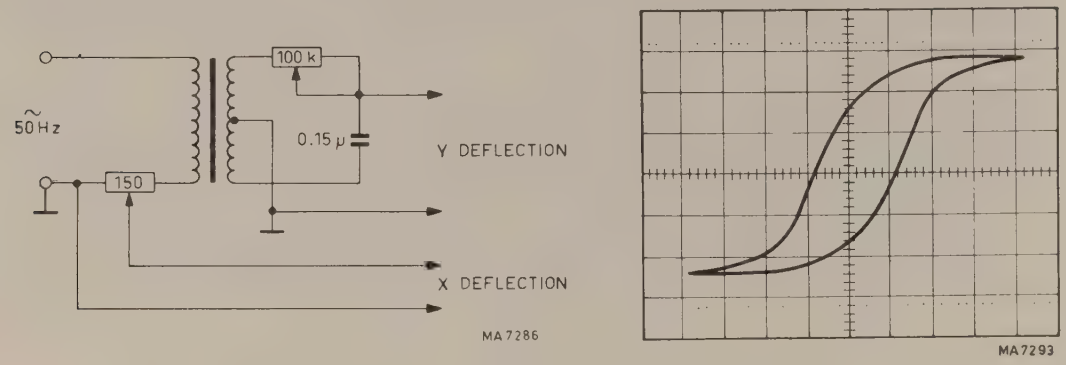


Fig. 2.9. Displaying a hysteresis loop, exact method

2.3.4.2. Displaying a diode characteristic

In displaying a diode characteristic, the current through the diode is plotted as a function of the voltage across the diode. For this, the circuit shown in Fig. 2.10. can be used. Voltage source V supplies a 50 Hz sine-wave voltage of approx. 20 V_{rms}.

The resistance R must be small compared to the expected internal resistance of the diode. The voltage across R, which is directly proportional to the anode current, is fed to the Y_B input. The anode voltage is applied to the Y_A input (TIME/cm switch to position X via Y_A). Then a curve is displayed which represents the relationship between anode current (vertical) and anode voltage (horizontal).

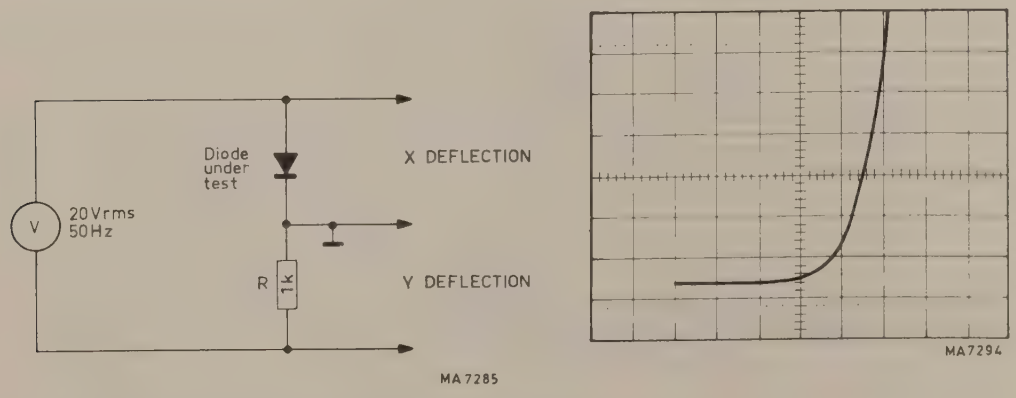


Fig. 2.10. Displaying the $I_A - V_A$ characteristic of a germanium diode

2.4. Some basic concepts

2.4.1. DEFINITIONS

2.4.1.1. Y deflection coefficient or sensitivity (V/cm or V/div.)

Indicates the peak-to-peak value of the input voltage required to bring about a deflection of the beam over a distance of 1 cm or 1 division in vertical direction.

2.4.1.2. Bandwidth or frequency range (Hz)
See Fig. 2.11.

This is the complete range of frequencies for which the deflection coefficient does not change more than 3 dB (approx. 30 %) with respect to the flat part of the frequency response curve. Beyond the 3 dB points, the response curve of good amplifiers as are used in the PM 3233 oscilloscope, roll off with 6 dB per octour to ensure an optimum pulse response.

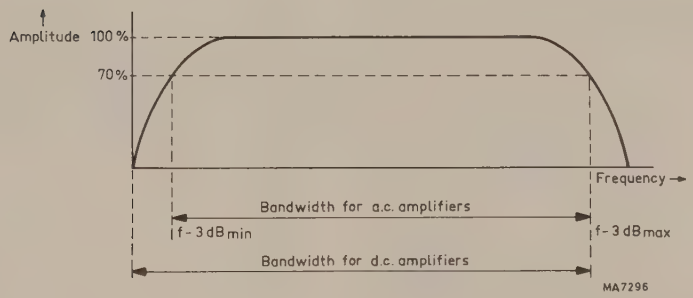


Fig. 2.11. Frequency response curve

2.4.1.3. Pulse rise time or fall time (ns)
See Fig. 2.12.

The time interval within which the voltage or current of the edge of a rectangular pulse passes from 10 % to 90 % (90 % to 10 %) of its full amplitude.
When amplifiers have a proper pulse response, the following relation between rise time (t_r) and −3 dB bandwidth (BW) is approximately true:
t_r (ns) . BW (MHz) = 350.

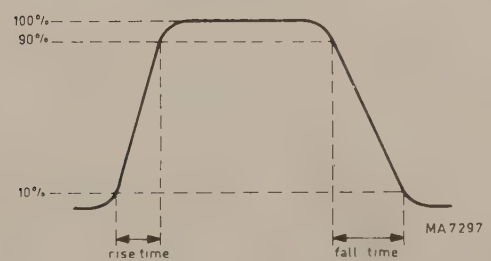


Fig. 2.12. Pulse rise and fall time

2.4.1.4. Overshoot (%)
See Fig. 2.13.

Overshoot is that part of the initial response which exceeds the steady-state value of the response to a rectangular pulse. It is expressed as a percentage of the steady-state value.

$$\text{Overshoot} = \frac{\Delta A}{A} \cdot 100\ \%$$

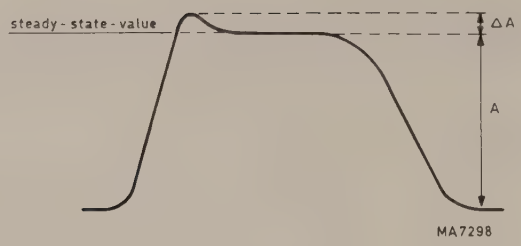


Fig. 2.13. Overshoot

2.4.1.5. Pulse tilt, also known as droop or sag (%)
See Fig. 2.14.

This is the difference between the initial and final amplitude of the representation of a rectangular pulse or square-wave, ignoring overshoot and other distortions.
It is expressed as a percentage of the initial amplitude and for a specified pulse duration.

$$\text{Pulse tilt} = \frac{\Delta A}{A} \cdot 100\ \%$$

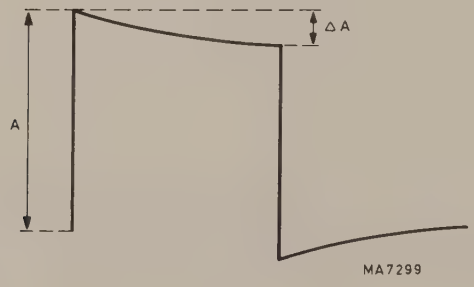


Fig. 2.14. Pulse tilt

2.4.1.6. Other pulse distortions
See Figs. 2.15. & 2.16. & 2.17.

Fig. 2.15. Ringing
Fig. 2.16. Preshoot
Fig. 2.17. Rounding

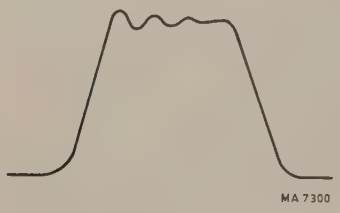


Fig. 2.15. Ringing

Fig. 2.16. Preshoot

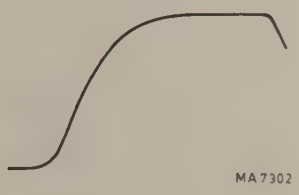


Fig. 2.17. Rounting

2.4.1.7. Pulse duration or width and repetition time
See Fig. 2.18.

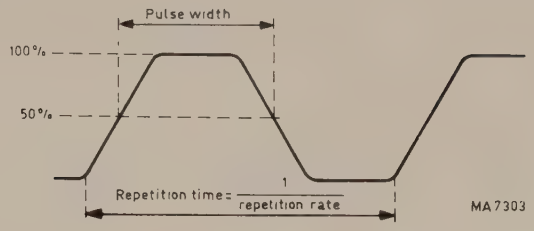


Fig. 2.18. Pulse width

2.4.1.8. Input impedance (MOhm//pF)

The input impedance is the final value calculated by combining the input resistance and capacitance in parallel.

2.4.1.9. Triggering

Triggering is the action of starting each individual sweep of the time base by means of a control voltage.
When there is no control voltage the time-base generator remains in a waiting position and no trace is visible on the screen.
Triggering can be either periodical or irregular.
In the triggered mode, any value of the time coefficient can be chosen independently of the period of the observed quantity, and without affecting the stability of the display.
Triggering has also the advantage that the time-base can be calibrated.

2.4.1.10. Hold-off circuit

This is a circuit incorporated in the time-base generator.
It prevents the sweep from being re-triggered until the spot has returned to its rest position and the circuit elements have completely relaxed.

2.4.2. DRIFT REDUCTION

The drift inherent in the sensitive d.c. coupled pre-amplifier is reduced by feedback via a control amplifier. We shall now calculate the effect of the control amplifier with reference to Fig. 2.19. in which A is the gain factor of the pre-amplifier and B that of the control amplifier. Resistors R are equal.

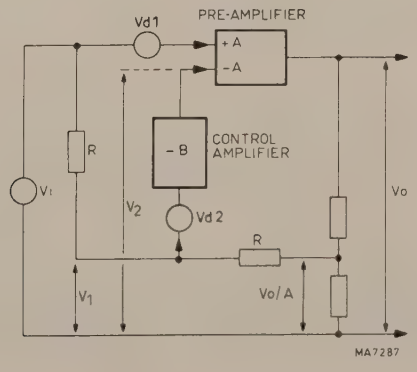


Fig. 2.19. Block diagram of the drift-reduction circuit

We regard the drift voltages from pre-amplifier and control amplifier as being due to d.c. voltage sources at the input (Vd1 and Vd2). We then find:

$$V1 = \frac{Vi + \frac{Vo}{A}}{2} \tag{1}$$

$$V2 = -B\,(V1 + Vd2) \tag{2}$$

$$Vo = A\,(V2 - Vi - Vd1) \tag{3}$$

It follows from (1) and (3) that:

$$V1 = \frac{Vi + \frac{A\,(V2 - Vi - Vd1)}{A}}{2} = \frac{V2 - Vd1}{2}$$

Substituting this result in (2) gives:

$$V2 = -B\,(\frac{V2 - Vd1}{2} + Vd2) \qquad \text{or}$$

$$V2\,(1 + \frac{B}{2}) = \frac{B}{2}\,Vd1 - BVd2 \qquad \text{or}$$

$$V2 = \frac{BVd1}{2 + B} - \frac{BVd2}{1 + \frac{B}{2}}$$

Substituting this result in (3) gives:

$$\frac{Vo}{A} = (\frac{B}{2 + B} - 1)\,Vd1 - \frac{BVd2}{1 + \frac{B}{2}} - Vi \qquad \text{or}$$

$$-\frac{Vo}{A} = Vi + \frac{2}{2 + B}\,Vd1 + \frac{B}{1 + \frac{B}{2}}\,Vd2 \qquad \text{or}$$

$$-\frac{Vo}{A} = Vi + \frac{1}{1 + \frac{B}{2}}\,Vd1 + \frac{2}{1 + \frac{2}{B}}\,Vd2$$

The last two terms represent drift voltages which are equivalent to a drift voltage:

$$Vd = \frac{1}{1 + \frac{B}{2}}\,Vd1 + \frac{2}{1 + \frac{2}{B}}\,Vd2$$

at the input.

We see that the drift of the pre-amplifier is reduced by a factor $(1 + \frac{B}{2})$. On the other hand, we have an extra drift due to the control amplifier, which is given by $\frac{2}{1 + \frac{2}{B}}\,Vd2 \approx 2Vd2$.

The drift of the control amplifier, however, is so low (because of strong thermal coupling of the amplifier transistors, and optimum design) that the term 2Vd2 can be neglected.

Drift reduction with reference to the circuit diagram of the PM 3233 is discussed in section 3.1.1.6.

2.4.3. SERIES AND SHUNT FEEDBACK AMPLIFIER

Most of the amplifier stages used in the PM 3233 are amplifiers with series and shunt feedback.
A typical example of such an amplifier is shown in Fig. 2.20.

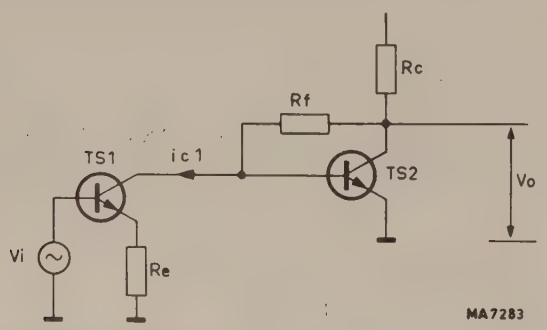


Fig. 2.20. Amplifier with series and shunt feedback

If we neglect the base current of TS2, it will be clear that the current through R_e also flows through R_f.
The transfer ratio $\frac{i_c}{v_i}$ in a series feedback amplifier stage is approximately $\frac{1}{R_e}$.
The transfer ratio $\frac{v_o}{i_c}$ in a shunt feedback amplifier stage is approximately R_f.

Thus, the voltage gain of the whole amplifier $A_v = \frac{v_o}{v_i}$ is near enough $\frac{R_f}{R_e}$ and depends only on the passive elements R_f and R_e.

2.4.4. THE DUAL-BEAM TUBE

The cathode-ray tube used in the PM 3233 oscilloscope is a dual-beam tube in which two beams are generated in one gun and can be deflected independently.
This arrangement is also known as split-beam tube.

In this tube, both time-base lines are exactly in parallel as they originate from one point and are under the influence of one common horizontal amplifier. Because the two traces originate from one gun, they slow little distortion in relation to one another.

The split-beam tube is very suitable for displaying signals with a low repetition rate at relatively fast sweep speeds, since it may be regarded as a tube with a chopper with an infinitely high chopper frequency.

2.4.5. FROM THE COLD INTO THE WARMTH

In section 1.2. Characteristics you can read that the instrument works within the specifications after a warm-up period of five minutes and at an ambient temperature between +5 °C and +40 °C.
There is, however, one exception. If you leave, for instance, your oscilloscope in your car overnight when it is freezing and then bring it into a room with a temperature of 25 °C the following morning, condensation will occur on the components.

The high-ohmic resistors in your oscilloscope then cease to be high-ohmic because of leakage currents over the condensation, and the oscilloscope does not work properly. In this situation, you must allow approximately 2 hours for your oscilloscope to acclimatize until all condensation has evaporated.

2.5. Brief checking procedure

2.5.1. STARTING POSITIONS OF THE CONTROLS

- Push-buttons Y_A SK4, + SK8 and BEAM SELECTOR A SK14 & B SK15 depressed.
- TIME/cm switch SK2 to .1 ms
- AMPL switches SK17 & SK18 to .1 V/cm
- MAGN switch SK1 to x1
- POSITION potentiometers R1, R11 and R12 to their mid-positions
- INTENS potentiometer R10 fully clockwise
- TIME/cm and AMPL potentiometers R2, R4 and R5 to CAL

Unless otherwise stated, the controls always occupy the same position as in the previous check.

2.5.2. C.R.T. POSITION

- Adjust FOCUS potentiometer R9 and INTENS potentiometer R10 for a well-defined display
- Centre both time-base lines, using POSITION potentiometers R1, R11 and R12
- Check that the time-base line runs exactly in parallel with the horizontal graticule lines.
  Correction possible with potentiometer R813 (Fig. 3.11. page 60).

2.5.3. VERTICAL CHANNELS

The check for channel Y_A is described, the relevant controls for Y_B are mentioned in brackets.

- Release BEAM SELECTOR B SK15 (A SK14)
- AC-0-DC switches SK16 & SK19 to 0
- AMPL switch SK17 (SK18) to 2 mV/cm
- Check that the time-base line remains within 4 mm in the centre of the screen. Correction possible with DC BAL potentiometer R6 (R7).
- AC-0-DC switch SK16 (SK19) to DC
- Check that the time-base line has not moved more than 4 mm. Correction possible with potentiometer R126 (R326), Fig. 3.13. page 61.
- AMPL switch SK17 (SK18) to .1 V/cm
- Apply a square-wave voltage of 600 mV_{p-p} ±0,5 %, 2 kHz, to Y_A (Y_B) input socket BU3 (BU5)
- Check that the trace height is 6 cm ±2 %.
  Correction possible with R111 (R311), Fig. 3.13.
- Increase the frequency of the input voltage to 10 MHz.
- Check that the trace height is at least 4,2 cm.

2.5.4. X VIA Y_A

- Depress BEAM SELECTOR A SK14 and B SK15
- Set TIME/cm switch SK2 to X via Y_A
- AC-0-DC switch SK19 to 0
- Apply a square-wave voltage of 600 mV_{p-p} ±0,5 %, 2 kHz, to Y_A input socket BU3
- Check that the trace width is 6 cm ±3 %.
  Correction possible with potentiometer R601 (Fig. 3.12. page 60).

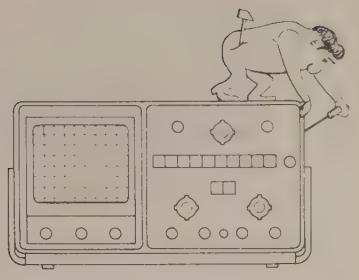
2.5.5. TIME-BASE

– Check the time-coefficient in position 20 μs of TIME/cm switch SK2 by means of time markers. Tolerance ±5 %. Correction possible with potentiometer R534 (Fig. 3.12.).
– Check the other time-coefficients; tolerance ±5 %.

2.5.6. TRIGGERING

– Apply a sine-wave voltage of 100 mV_{p-p}, 10 MHz, to Y_A input BU3
– Check that it is possible to adjust LEVEL potentiometer R3 for a stationary display.

3. Service data



3.1. Circuit description

3.1.1. CHANNEL Y_A VERTICAL AMPLIFIER

3.1.1.1. General

The vertical amplifier provides control of the input coupling, Y deflection coefficient and gain.
Furthermore, a drift-reduction circuit and a trigger pick-off stage are part of the amplifier circuitry.

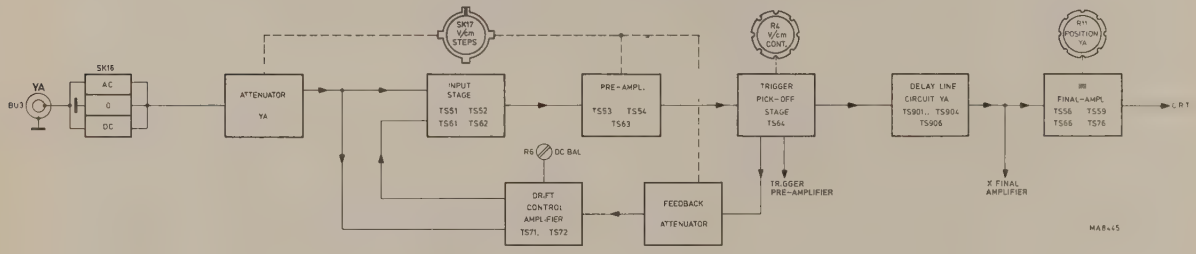


Fig. 3.1. Vertical amplifier, channel Y_A

3.1.1.2. Input coupling

Input signals connected to Y_A socket BU3 can be a.c. coupled, d.c. coupled or internally disconnected.
In position DC of AC-0-DC switch SK16, the input signal is coupled direct to the step attenuator.
In the AC position, there is a capacitor (C26) in the signal path.
This capacitor prevents the d.c. component of the input signal from being applied to the amplifier.
In position 0, the signal path between the input socket and the amplifier input is interrupted, the latter being earthed.
At the same time, blocking capacitor C26 is discharged via resistor R26, to prevent damage of the circuit under test by a possible high charge.

3.1.1.3. Input attenuator

The input attenuator is a frequency-compensated, high-ohmic voltage divider with twelve positions.
Both attenuator sections contain trimmers which are adjusted for optimum square-wave response and others that maintain the same input capacitance (20 pF) for each position of AMPL. switch SK17.
The input capacitance of both channels can be equalized using trimmer C235.

The attenuator works in conjunction with a gain control in the pre-amplifier (see also section 3.1.1.5.).
The gain of the pre-amplifier is selected together with the relevant attenuator section, by means of AMPL. switch SK17.

3.1.1.4. Input stage

Input source-follower TS51 and emitter follower TS52 provide a high input impedance to the step attenuator and a low-impedance source to the pre-amplifier.
The input source-follower is protected by diodes GR53 and GR54.
If there is a maximum positive-going voltage change, the field-effect transistor can deal with it. If the change goes negative beyond the threshold established by zener diode GR54, diode GR53 starts conducting and the excess is short-circuited to earth.
The non-driven part of the input stage (TS62) is decoupled for high frequencies, by means of capacitor C59.
This part of the input stage receives the d.c. balance voltage and the drift-feedback voltage from the drift-feedback amplifier.

3.1.1.5. Pre-amplifier

The pre-amplifier comprises two amplifier stages, one with series feedback (TS53 & TS63) and one with shunt feedback (TS54). The overall gain of the pre-amplifier is chiefly determined by the ratio of the shunt-feedback resistance (R97 & R99) and series-feedback resistance (resistance between the emitters of transistors TS53 and TS63). The latter resistance, and thus the overall gain of the pre-amplifier, can be varied by connecting resistors in parallel to resistor R62. These parallel resistors are selected, together with a section of the input attenuator, by means of AMPL. switch SK17. In this way twelve different deflection coefficients are obtained (see also section 3.1.1.3.).
Potentiometers R64 and R99 are pre-set controls for the gain of the pre-amplifier at different settings of AMPL. switch SK17.

3.1.1.6. Drift-reduction circuit

In the event of no drift phenomena in the pre-amplifier, attenuator R102, R40...R44 provides at junction R128-C67 a voltage which is exactly equal to, but in anti-phase with, the voltage at the gate of field-effect transistor TS51 (junction R52-R54). This is true because attenuator R102, R40...R44 is switched over together with the gain switch of the pre-amplifier. Junction R128-R52 will then be on earth level (virtual earth point).

When there is a drift phenomenon, junction R128-R52 carries half the drift voltage. This voltage is amplified by transistors TS71 and TS72 and, in the correct phase, applied to field-effect transistor TS62. The resulting feedback brings the output level of the amplifier back to 0 V. The d.c. level of the feedback is adjusted with DC BAL. potentiometer R6.

In order to prevent the base currents of transistors TS71 and TS72 from flowing through high-ohmic resistors R128 and R52, they are compensated for by means of potentiometer R126 and resistors R127 and R129. Resistor R131 equalizes the base impedances of transistors TS71 and TS72.

Capacitor C59 limits the feedback at approximately 100 Hz.
Therefore, a variation of the value of potentiometers R64 & R99 causes a variation in the top of a l.f. square-wave voltage. When potentiometers R64 and R99 are correctly adjusted, the pulse top is straight.

3.1.1.7. Trigger pick-off stage

Transistor TS64 serves a twofold purpose. It acts as an amplifier stage for the channel Y_A triggering signal further discussed in section 3.1.3.1., and as an emitter-follower for the signal to be tested.
The test signal is applied to the delay line circuit via AMPL. potentiometer R4 in the emitter circuit of transistor TS64. This potentiometer provides an uncalibrated, continuous control of the deflection coefficients.

3.1.1.8. Delay line circuit

The delay line circuit consists of an assymmetrically driven differential amplifier (TS902 & TS903), which is coupled with emitter followers (TS901, TS904 & TS906) at the input as well at the output.
Emitter follower TS906 serves the symmetry. From resistor R903 in the emitter circuit of transistor TS901 the signal is, via the delay line, applied to the differential amplifier. The delayed test signal is coupled to the output stage via emitter follower TS904, which reduces the effect of the input capacitance of the output stage on the differential amplifier.
The input of the delay line is terminated by R903//R904 and its output by R907.

3.1.1.9. Output amplifier

From the emitter of emitter follower TS904, the signal is applied to the base of transistor TS66 which is part of a differential amplifier. By varying the series feedback of this amplifier by means of potentiometer R111, the overall gain of the Y_A channel can be set. The RC combination R113-C62 corrects the gain factor at high frequencies.

The Y shift voltage derived from POSITION potentiometer R11 is applied to the base of transistor TS67. If BEAM SELECTOR switch SK14 is not depressed, the voltage on the base of TS67 is such that the trace is shifted off the screen and cannot be brought back with the POSITION potentiometer.

From the differential amplifier the signal is fed to the final stage which consists off two single-ended push-pull sections, viz. TS57, 58, 59, 68 and TS69, 73, 74, 76. From these two sections, the signal is applied to the Y deflection plates.
The circuit with transistor TS56 will be discussed together with the c.r.t. circuitry (section 3.1.6.3.).
In position X via Y_A, the signal is fed to the X output amplifier via emitter follower TS75. In this case the channel Y_A output amplifier is inoperative.

3.1.2. CHANNEL Y_B VERTICAL AMPLIFIER

As this channel is identical to channel Y_A with exception of the circuitry for external X deflection, the description of channel Y_A also holds good for channel Y_B. Components are assigned in the 200-299 range (corresponding to numbers in the 1-99 range for channel Y_A), in the 300-399 range (corresponding to range 100-199 in channel Y_A) and in the 1000-1099 range (corresponding to range 900-999 in channel Y_A).

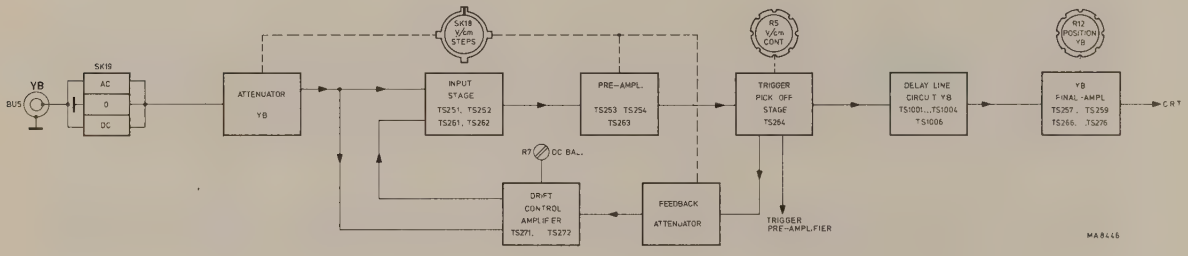


Fig. 3.2. Vertical amplifier, channel Y_B

3.1.3. TRIGGERING

The trigger unit comprises the following circuits:
a trigger pre-amplifier, a differential amplifier, a sync separator and a trigger-pulse shaper.
The circuit diagram shows all triggering push-buttons in their released positions.

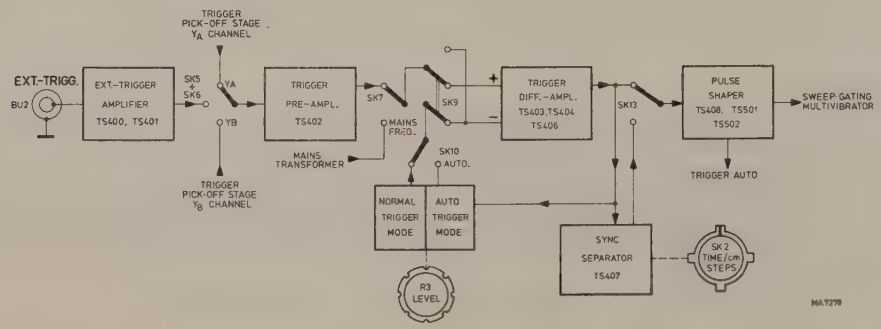


Fig. 3.3. Trigger unit

3.1.3.1. Trigger pre-amplifier for internal triggering

If Y_A push-button SK4 is depressed, trigger pick-off stage TS64 in the Y_A channel and transistor TS402 form together an amplifier with series and shunt feedback. Y_A push-button SK4 is only a mechanical release for Y_B push-button SK5 and is, therefore, not included in the circuit diagram; thus, SK4 depressed corresponds to SK5 released. The gain of trigger pre-amplifier is determined by the ratio of the shunt feedback resistance R412 and the series-feedback resistance in the emitter circuit of transistor TS64.

If Y_B push-button SK5 is depressed, trigger pick-off stage TS264 in the Y_B channel and transistor TS402 form the trigger pre-amplifier.

3.1.3.2. Trigger pre-amplifier for external triggering

If EXT. push-button SK6 is depressed, transistors TS402 and TS401 form together a similar amplifier with series- and shunt-feedback as described in section 3.1.3.1. . Transistor 400 serves as an inverter for the triggering signals so that the next stage is driven in the correct phase. Moreover, this transistor improves the stability of the pre-amplifier. The external trigger input is protected against excessive positive intput voltages by means of diodes GR401 and GR402.

3.1.3.3. Long-tailed pair circuit (differential amplifier)

The following description applies to internal triggering.
From the pre-amplifier the triggering signal is fed to the long-tailed pair circuit with transistors TS403 and TS404. The signal is applied to the base of transistor TS403 if + push-button SK8 is depressed and to the base of TS404 if – push-button SK9 is depressed.
This allows triggering on either the positive or negative slope of the signal. The + push-button SK8 is a mechanical release for – button SK9 and is, therefore, not included in the circuit diagram.

A d.c. voltage which is variable with LEVEL potentiometer R3' is applied to the base of the non-driven transistor of the long-tailed pair circuit.
As a long-tailed pair circuit amplifies the difference of the base voltages, the setting of potentiometer R3' determines which part of the signal will be amplified and, thus, the trigger level.
The output signal of the long-tailed pair circuit is fed to emitter follower TS406. If AUTO push-button SK10 is depressed, the a.c. component of the emitter signal of TS406 is applied to the full-wave rectifier with diodes GR404 and GR406. The rectified voltage across LEVEL potentiometer R3'' corresponds to the peak-to-peak value of the a.c. component of the triggering signal. This d.c. voltage is fed to the base of transistor TS404 of the long-tailed pair circuit. The result is that in the auto mode the trigger level range corresponds to the peak-to-peak value of the triggering signal.

3.1.3.4. Synchronisation separator

If T.V. push-button SK13 is depressed, a synchronisation separator for television is inserted into the triggering signal path. The sync separator comprises transistor TS407. The television signal is clipped in such a way that only the synchronising pulses reach the collector of transistor TS407. In positions .2 μs to 20 μs (TV LINE) of TIME/cm switch SK2, these pulses are supplied direct to emitter follower TS408.
In positions 50 μs to .5 s (TV FRAME) the composite synchronising signal is integrated by means of R439, C412, GR407, R442 and C413 at such a time constant that the frame pulses are separated. The separated pulses are applied to emitter follower TS408.

3.1.3.5. Trigger-pulse shaper

The trigger-pulse shaper comprises transistors TS501 & TS502 in Schmitt-trigger configuration. With a repetitive trigger signal, a square-wave voltageof constant amplitude and width arises at the collector of TS502. This square-wave voltage is differentiated by C502 and R514 into narrow positive and negative pulses. The positive pulses are short-circuited by GR501 so that sweep-gating multivibrator TS503-TS504 receives only negative pulses.

3.1.4. TIME-BASE GENERATOR

The time-base generator comprises a sweep-gating multivibrator, a sawtooth generator, a hold-off circuit and an auto circuit.

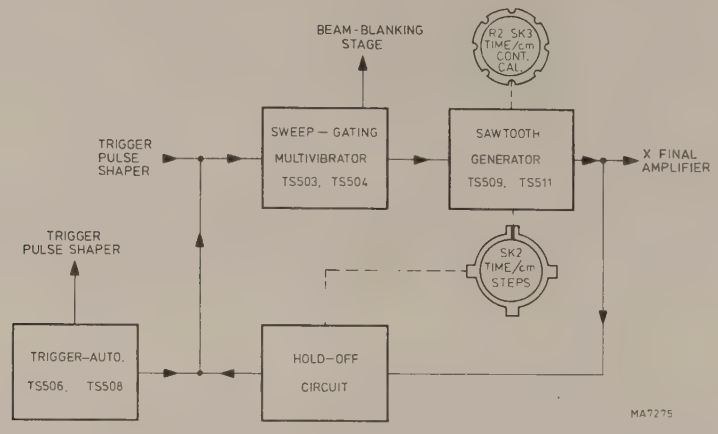


Fig. 3.4. Time-base generator

3.1.4.1. Sweep-gating multivibrator and sawtooth generator

The sweep-gating multivibrator comprises transistors TS503 and TS504 in Schmitt-trigger configuration.
In the state transistor TS503 cut off and transistor TS504 conducting, transistor TS509 is cut off.
Then the time-base capacitor selected with TIME/cm switch SK2 is charged with a constant current supplied by transistor TS511. The rate of voltage increase which determines the sweep time or time coefficient, is inversely proportional to the capacitance of the selected capacitor and direct proportional to the current through transistor TS511. This current is determined by the base voltage of transistor TS511, the voltage of which can be set by the TIME/cm vernier control R2 and preset by potentiometers R534 and R539.
The charging current is, moreover, determined by the value of the emitter resistors of transistor TS511, which are also switched over by TIME/cm switch SK2.
The sawtooth voltage is taken off by a cascade circuit consisting of emitter followers TS512 and TS513 and applied to both the hold-off circuit and the horizontal amplifier.

Via the hold-off circuit, the sawtooth voltage is fed back to the input of the sweep-gating multivibrator whose input level is preset with stability potentiometer R553. At a certain value of the sawtooth voltage, in the automatic mode, the sweep-gating multivibrator is set to the state transistor TS503 conducting and transistor TS504 cut off. In the other trigger modes the switching over occurs when the sum of sawtooth voltage and trigger pulses reaches a certain value. Then transistor TS509 starts conducting and the time-base capacitor is discharged via this transistor. This cycle is repeated upon arrival of the next trigger pulse.

3.1.4.2. Hold-off circuit

Due to the effect of diode GR504, the charge of the hold-off capacitor selected with TIME/cm switch SK2, cannot follow the decay of the sawtooth voltage.
The capacitor voltage will then decrease with an RC time which is sufficiently large to allow the sawtooth to reach its zero level and to ensure the decay of the switching phenomena. During this RC time, the input level of the sweep-gating multivibrator is so high that incoming trigger pulses have no effect.

3.1.4.3. Auto circuit

The AUTO circuit makes the time-base generator free-running when there are no trigger pulses.
The AUTO circuit works in every trigger mode, except when either AC push-button SK11 or DC push-button SK12 is depressed.

If there are trigger pulses, they are fed to the base of transistor TS506 of the AUTO circuit. As a result of this, the two transistors TS506 and TS508 of the AUTO circuit are conductive until capacitor C506 is discharged. The voltage at the cathode of diode GR502 is then so positive that the latter remains blocked and the working of the sawtooth generator, as described above, is not affected.

As soon as there are no trigger pulses, capacitor C506 will be charged and diode GR502 becomes conductive. The voltage level at the input of the sweep-gating multivibrator TS503-TS504 then drops to such a value that the multivibrator switches over and a sawtooth is formed. This occurs immediately after the drop of the hold-off pulse, i.e., the time-base generator is free-running.

3.1.5. HORIZONTAL AMPLIFIER

In the time positions of TIME/cm switch SK2 the sawtooth voltage of the time-base generator is fed to the base of transistor TS603. The sawtooth is also applied, for external purposes, to TB OUT socket BU6 via emitter follower TS516.

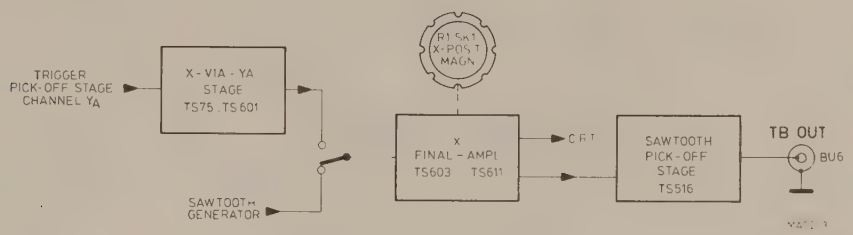


Fig. 3.5. Horizontal amplifier

In position X via Y_A of TIME/cm switch SK2, the external X deflection voltage applied to the Y_A channel is fed from transistor TS64 to the base of transistor TS603, via emitter follower TS75 and amplifier TS602. The external X deflection voltage is also applied to TB OUT socket BU6, via emitter follower TS516.

The horizontal output amplifier comprises two stages.
The first one with transistors TS603 and TS604 is provided with series-feedback.
The second one consists of two single-ended push-pull sections TS607-608 and TS609-611 with shunt-feedback.
From the latter stage the deflection signal is fed to the c.r.t.

The gain of the output amplifier is determined by the shunt-feedback resistors R628 and R633, and the emitter resistance of transistors TS603 and TS604.
X MAGN switch SK1 allows a gain control in two steps.
If switch SK1 is closed (X MAGN knob pulled out), the series-feedback in the emitter circuit of transistors TS603 and TS604 is decreased in such a way that the gain of the output amplifier is increased by a factor of 5.
In the latter mode, the magnified mode, the gain can be preset by means of potentiometer R617 and in the normal mode by means of potentiometer R618.
In position X via Y_A of TIME/cm switch SK2, switch SK1 is bypassed and the output amplifier works in the magnified mode.

The horizontal shift voltage comming from X POSITION potentiometer R1 is supplied to the base of transistor TS604. Transistor TS606 acts as a constant emitter-current source for amplifier stage TS603-TS604.

3.1.6. CATHODE-RAY TUBE CIRCUITRY

3.1.6.1. General information

The c.r.t. circuitry provides control for brightness, focus and astigmatism, and correction possibilities for barrel and pin-cushion distortion and the position of the trace. The blanking circuit is also part of the c.r.t. circuitry.

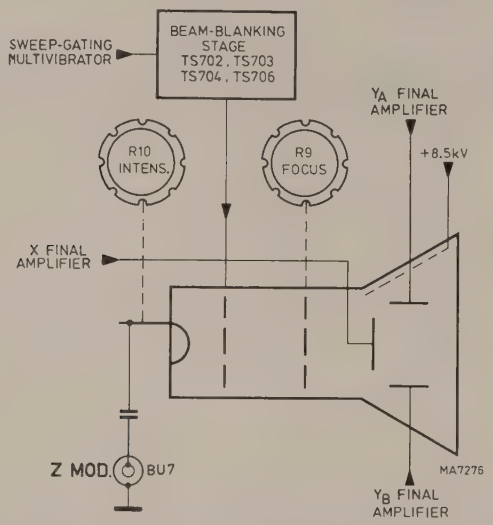


Fig. 3.6. Cathode-ray tube circuitry

3.1.6.2. C.r.t. circuit

By means of INTENS potentiometer R10 the brightness of the display can be continuously controlled.
The maximum beam current is set by potentiometer R801.
The control range of the INTENS potentiometer can be preset by means of potentiometer R802.

A brightness modulation facility, a.c. coupled, is provided on Z MOD input socket BU7.
The display can be focused by means of FOCUS potentiometer R9. In a split-beam c.r.t. as used in this oscilloscope, focusing has certain consequences.
These consequences and their remedies are discussed in section 3.1.6.3.

Astigmatism is corrected on a low-impedance level by means of potentiometer R809 via emitter follower TS801.
With the aid of potentiometer R812 barrel and pin-cushion distortion is corrected.
Potentiometer R813 provides trace rotation control and allows the time-base line to be accurately aligned with the horizontal graticule lines.

3.1.6.3. Focusing in the split-beam c.r.t.

In the split-beam c.r.t. the electron beam is split into two parts which form the traces of the Y_A and Y_B channel. Both traces are controlled independently by the controls of both channels. The electron beam is focused, however, before it is split and, therefore, there is only one focus control. This mono-knob control of the focus has the follower consequence.

Assume a focus setting as illustrated in Fig. 3.7.1.
Then the focusing point is exactly on the screen.
When the FOCUS potentiometer R9 is rotated, the focusing point is displaced to a point either side of the screen (Figs. 3.7.2. & 3.7.3.). This results in both traces moving away from each other. The more clockwise or anti-clockwise the FOCUS control is turned, the further the traces move apart.

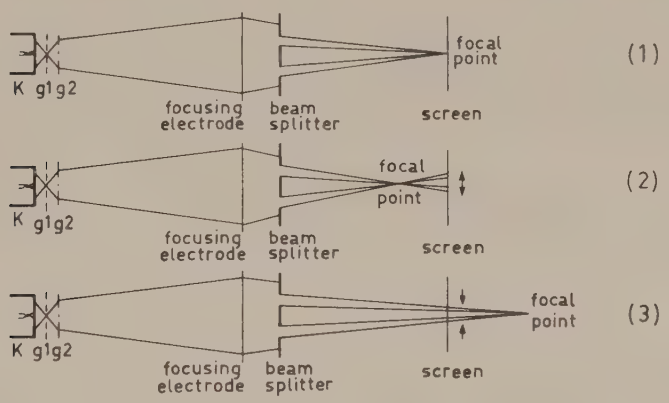


Fig. 3.7. Effect of the focus control

To compensate for this trace shift, an extra shift voltage is fed to the vertical amplifier channels via transistor TS56. The magnitude of this voltage is controlled by potentiometer R9' which is part of FOCUS tandem potentiometer R9. The control is such, that the displacement caused by operation of the FOCUS control is compensated for.
The compensation voltage for channel Y_A is obtained from the emitter of transistor TS56 and that for channel Y_B from the collector.
The compensation is so effective that the maximum displacement of each trace, caused by rotating FOCUS potentiometer R9 from fully anti-clockwise to fully clockwise, does not exceed 2 mm.

3.1.6.4. Blanking circuit

The blanking circuit blanks the c.r.t. during the fly-back of the time-base and unblanks the c.r.t. during the sweep and constantly if TIME/cm switch SK2 occupies position X via Y_A.
The blanking circuit operates on a low voltage level and comprises an a.c. and a d.c. path.
Transistor TS706 is driven by the collector signal of transistor TS504 in the sweep-gating multivibrator.
Transistor TS706 forms together with transistor TS704 a single-ended push-pull circuit.

- **A.C. Path:** The amplified a.c. components of the blanking signal are fed direct to the Wehnelt cylinder of the c.r.t. via H.T. capacitor C707.
- **D.C. Path:** For the d.c. component of the blanking signal, the signal of oscillator TS702 & TS703 is used. The oscillator signal is modulated with the blanking signal. The amplified modulated signal on the collector of transistor TS703 is via capacitor C706 fed to demodulator GR702-R713. After demodulation, also the d.c. component of the blanking signal is available.

The a.c. and d.c. amplifications are equalized by means of potentiometer R711.

3.1.7. CALIBRATION VOLTAGE

The calibration voltage generator consists of free-running multivibrator TS750 & TS751. The generator frequency is approximately 2 kHz. The amplitude of the generated square-wave voltage is kept at a constant value by means of zener diode GR751. The exact value of the calibration voltage is set with the aid of potentiometer R761.

3.1.8. POWER SUPPLY

The power supply comprises the mains transformer, stabilized supply and converter, and the circuit for the graticule illumination.

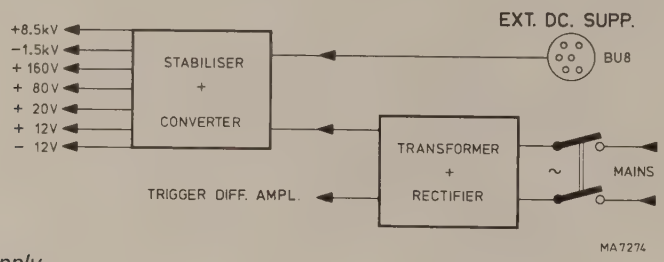


Fig. 3.8. Power supply

3.1.8.1. Mains transformer

Mains transformer TS801 has three primary windings (S1, S1' and S1'') which, together with the secundary winding (S2//S3), can be combined by means of voltage adapter SK21. This combination allows the instrument to be used with mains voltages of 110 V, 127 V, 220 V and 240 V.

The voltage on secundary winding is full-wave rectified. The resulting negative d.c. voltage, or alternatively a negative d.c. voltage on EXT DC SUPPLY input socket BU8, is applied to the voltage stabilizer and converter.

Part of the a.c. voltage on secundary winding of the mains transformer is fed to MAINS trigger source switch SK7, to enable internal triggering on the mains frequency.

3.1.8.2. Converter and stabilized power supply

The converter is a regenerative square-wave generator operating at a frequency of approx. 18 kHz.
A basic diagram of the converter is shown in Fig. 3.9.

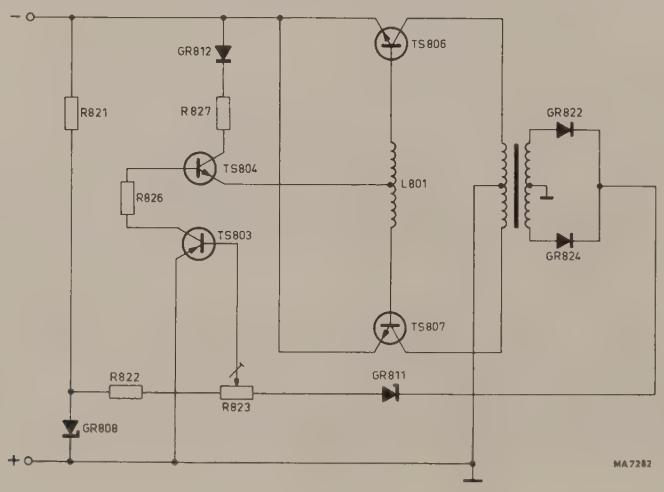


Fig. 3.9. Basic diagram of the converter

In the converter, transistors TS806 and TS807 function as switches and regulators and alternately connect the negative supply voltage to either end of the primary of L801/802. Assume that transistor TS806 has a slightly higher current gain than TS807. Then the positive voltage from the feedback winding quickly drives transistor TS806 into saturation. The current in the top half of the primary of L801/802 increases linearly at a rate determined by the inductance in the primary. This current increase continues until the iron in transformer coil L801 is saturated.
Then the magnetic lines of flux stop changing and consequently no voltage is induced any longer in the feedback winding. When its base drive ceases, transistor is cut off. This reverses the polarity of the feedback voltage and transistor TS807 is turned hard on. The bottom half of the primary then passes an increasing current until the core is saturated in the opposite direction. The subsequent absence of feedback voltage initiates the switching back to TS806 and the cycle starts again.

The regulation works as follows. When an input voltage is applied to the converter, the negative voltage across Zener diode GR808 turns transistor TS803 fully on, as there is no positive voltage from Zener diode GR811.

Then a bias current starts flowing from earth via transistor TS803 through resistor R826, through the base-emitter junction of transistor TS804 (operating as a diode since diode GR812 interrupts the collector circuit) and from base to emitter of both transistors TS806 and TS807.
As there is then an a.c. voltage across the secundary of L801/802, diodes GR822 and GR824 produce a positive d.c. voltage. This voltage reduces the current through transistors TS803 and TS804 sufficiently to limit the drive to transistors TS806 and TS807 and produce the desired output level. The setting of potentiometer R823 determines the value of the regulated output voltage. Possible differences from the set output voltage are fed back via Zener diode Gr811 to transistor TS803 so that the drive of transistors TS806 and TS807 is adapted so as to compensate for the differences. This also applies to mains voltage fluctuations.

After rectifying, the secundary voltages +12 V (reference), −12 V, +20 V, +80 V, +160 V, −1500 V and high voltage +8500 V are obtained. The voltage quintupler which supplies the +8500 V cannot be repaired and must be replaced when it breaks down.

All supply voltage except the +8500 V and the −1500 V can be continuously short-circuited without damage to the components. Resistor R827 limits the maximum base current drive to transistors TS806 and TS807 and thus the maximum power output which can be drawn from the converter.
Resistor R826 limits the collector current when the output is short-circuited and the switching action is stopped, thereby holding the dissipated power in transistors TS806 and TS807 at a safe level. Thus, the power supply of the oscilloscope is fully protected against short-circuits. A short-circuit is indicated either by a squeeking noise coming from the power supply or by the pilot lamp failing to light up.

3.1.8.3. Illumination circuit

The graticule of the c.r.t. can be illuminated by means of bulbs LA1 and LA2. The intensity can be varied with the aid of ILLUM potentiometer R8 which controls the collector current (which is the current through the bulbs) of transistor TS802. The illumination circuit is not short-circuit proof.

3.2. Checking and adjusting

3.2.1. GENERAL INFORMATION

All adjusting elements have been listed in the headings of the various sections.
The tolerances mentioned in the following text apply to newly adjusted instruments only. The values may differ from those given in chapter 1.2. CHARACTERISTICS.

3.2.2. POWER SUPPLY

3.2.2.1. Mains current

- Check that the mains voltage adapter (SK21) has been set to 220 V and connect the instrument to such a voltage (frequency 50 Hz)
- Switch the oscilloscope on and check that the pilot lamp lights up
- Check that the current consumption does not exceed 200 mA (measured with a moving-iron meter)

3.2.2.2. Supply voltages (R823)

- Check that the voltage across capacitor C833 is +12 V, + or –20 mV; if necessary, readjust potentiometer R823 (Fig. 3.10).
- Check the supply voltages in accordance with the following table:

Voltage across	Required value	Max. allowable ripple
C833 (Fig. 3.10.)	+ 12 V, ± 30 mV	4 mV_{p-p}
C836 (Fig. 3.10.)	– 12 V, ±400 mV	6 mV_{p-p}
C831 (Fig. 3.10.)	+ 20 V, ±900 mV	40 mV_{p-p}
C829 (Fig. 3.10.)	+ 80 V, ± 2 V	250 mV_{p-p}
C828 (Fig. 3.10.)	+160 V, ± 3 V	100 mV_{p-p}

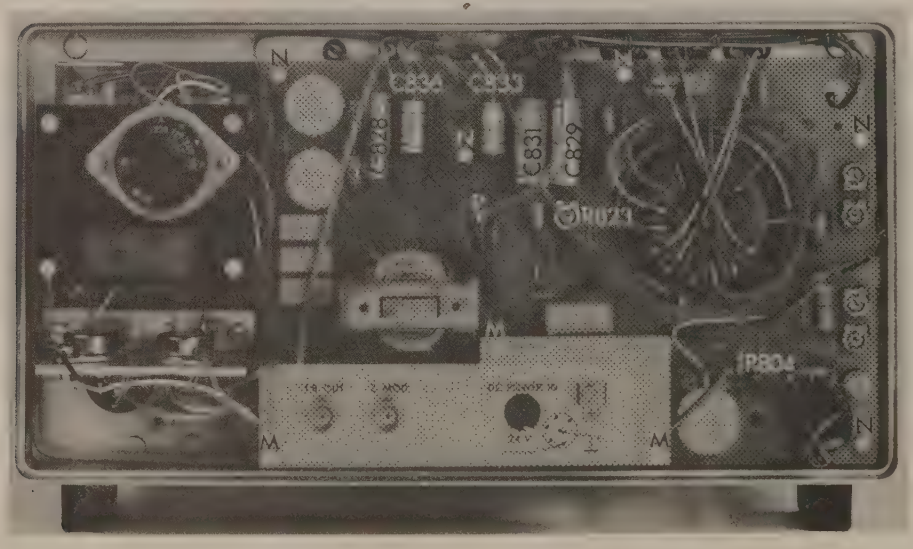


Fig. 3.10. Adjusting and dismantling

- Vary the a.c. voltage to which the instrument is connected between 198 V and 242 V
- Check that the supply voltages do not vary more than 0.5 % and that the ripple voltages do not exceed the values mentioned in the table above.

3.2.3. CATHODE-RAY TUBE CIRCUIT

3.2.3.1. Adjustment to display time-base lines

> ϟ 1500 V **Use a well-insulated screw-driver to protect both yourself and the circuitry.**

3.2.3.1.1. Time-base (R801, R802, R553)

- Turn potentiometers R801 and R802 (Fig. 3.11.) clockwise and potentiometer R553 (Fig. 3.12.) anti-clockwise
- Turn INTENS potentiometer R10 clockwise
- Set X POSITION potentiometer R1 to its mid-position and depress MAGN switch SK1
- Set the POSITION potentiometers R11 and R12 to their mid-positions
- Set TIME/cm switch SK2 to 1 ms
- Depress BEAM SELECTOR switches A SK14 and B SK15
- Set AMPL switches SK17 and SK18 to .1 V/cm; there should be a display of two time-base lines
- See for adjusting with components R801 and R802 point 3.2.3.6.

3.2.3.1.2. Time-base stability (R553)

- Depress Y_A switch SK4, + switch SK8, AC switch SK11 and BEAM SELECTOR switch A SK14
- Turn potentiometer R553 (Fig. 3.12.) clockwise until the time-base line disappears
- Depress AUTO switch SK10. A time-base line must become visible. If necessary, readjust potentiometer R553.

3.2.3.2. Trace rotation (R813)

- Depress AUTO switch SK10 and BEAM SELECTOR switch A SK14
- Set AC-0-DC switch SK16 to 0
- Centre the time-base line by means of POSITION potentiometer R11
- Check that the time-base line runs exactly in parallel with the horizontal lines of the graticule. If necessary, readjust trace rotation potentiometer R813 (Fig. 3.11.)

3.2.3.3. Beam correction

- Depress AUTO switch SK10 and BEAM SELECTOR switches A SK14 and B SK15
- Set AC-0-DC switches SK16 and SK19 to 0
- Position the traces symmetrically around the centre of the screen using POSITION potentiometers R11 and R12
- Adjust INTENS potentiometer R10 for a low brightness
- Check that both traces are equally bright. If necessary, slacken screw S (Fig. 3.11.) and rotate magnet T (Fig . 3.11.) until both traces have the same brightness. Then, tighten screw S without disturbing the adjustment

3.2.3.4. Focus and astigmatism (R809, R804)

- Depress AUTO switch SK10 and BEAM SELECTOR switches A SK14 and B SK15
- Set TIME/cm switch SK2 to .2 ms and TIME/cm potentiometer to CAL
- Set AMPL switches SK17 and SK18 to .1 V and AMPL potentiometers R4 and R5 to CAL
- Set INTENS potentiometer R10 for normal brightness
- Set AC-0-DC switches SK16 and SK19 to DC
- Apply a sine-wave signal of 400 mV_{p-p}, 2 kHz, to Y_A input socket BU3 and Y_B input socket BU5

> **Use an insulated screw-driver**

- Adjust FOCUS potentiometer R9 and astigmatism potentiometer R809 (Fig. 3.11.) for sharp, well-defined traces. Find the setting that gives the best result for both channels
- Set FOCUS potentiometer R9 in mid-stroke position and check for sharp traces. If necessary select a different value for R804.

3.2.3.5. Barrel & pin cushion distortion (R812)

- Set TIME/cm switch SK2 to 1 ms and TIME/cm potentiometer R2 to CAL
- Set AMPL switch SK17 to 10 mV/cm and AMPL potentiometer R4 to CAL
- Depress BEAM SELECTOR switch A SK14
- Set AC-0-DC switch SK16 to DC
- Apply a sine-wave signal of 1 $V_{p\text{-}p}$, 2 kHz, to Y_A input socket BU3

Use an insulated screw-driver. Be careful not to make any short-circuits.

- Check that the displayed vertical lines are straight.
  If necessary, readjust potentiometer R812 (Fig. 3.11.)

3.2.3.6. Brightness (R711, R801, R802)

1500 V Use a well-insulated screw-driver to protect both yourself and the circuitry.

- Switch the instrument on at least 15 minutes before starting this check
- Depress Y_A switch SK4, + switch SK8, AUTO switch SK10 and BEAM SELECTOR switch A SK14
- Set AC-0-DC switch SK16 to 0
- Set AMPL switch SK17 to .1 V/cm
- Set INTENS potentiometer R10 for low brightness
- Set TIME/cm switch SK2 to 1 ms and TIME/cm potentiometer R2 to CAL
- Check that the time-base line shows a constant brightness over the entire length; if necessary, readjust potentiometer R711 (Fig. 3.12.)
- Check that the brightness remains constant in all other positions of TIME/cm switch SK2
- Depress AC switch SK11 — R553 (STEP 3.2.3.1.2.) MUST BE SE WILL HAVE JUST A TRACE
- Set TIME/cm switch SK2 to 1 ms
- Turn INTENS potentiometer R10 fully clockwise
- The spot must just be visible; if necessary, readjust potentiometer R801 (Fig. 3.11.)
- Depress AUTO switch SK10
- Set INTENS potentiometer R10 to 90° from its left-hand stop
- Check that the time-base line is barely visible; if necessary, readjust potentiometer R802 (Fig. 3.11.)

3.2.3.7. Focus correction

- Depress AUTO switch SK10 and BEAM SELECTOR switches A SK14 and B SK15
- Set AC-0-DC switches SK16 and SK19 to 0
- Set AMPL switches SK17 and SK18 to .1 V/cm and AMPL potentiometers R4 and R5 to CAL
- Shift the time-base lines on to the horizontal central graticule line with the aid of POSITION potentiometers R11 and R12
- Rotate FOCUS potentiometer R9 from fully anti-clockwise to fully clockwise and check that this does not cause the time-base lines to shift more than 2 mm

3.2.4. VERTICAL AMPLIFIERS

3.2.4.1. General information

The adjustments of the vertical amplifier channels Y_A and Y_B are identical. The knobs, sockets and adjusting elements of channel Y_B are shown in brackets after those of channel Y_A.

3.2.4.2. D.C. Balance (R6, R7)

- Depress Y_A (Y_B) switch SK4 (SK5), + switch SK8 and BEAM SELECTOR switch A SK14 (B SK15)
- Set AC-0-DC switch SK16 (SK19) to 0
- Set AMPL potentiometer R4 (R5) to CAL
- Check that the trace does not shift if AMPL switch SK17 (SK18) is switched from .1 V/cm to 2 mV/cm. If necessary, readjust DC BAL R6 (R7). During the adjustment, the trace must be kept in the centre of the screen by means of POSITION potentiometer R11 (R12)
- Check that the position of the trace is the same in positions 2, 5, 10, 20, 50 and 100 mV/cm of AMPL switch SK17 (SK18); maximum allowable difference 4 mm

3.2.4.3. Gate current (R126, R326)

- Depress Y_A (Y_B) switch SK4 (SK5), BEAM SELECTOR switch A SK14 (B SK15) and + switch SK8
- Set AMPL switch SK17 (SK18) to 2 mV/cm
- Check that the trace does not jump when AC-0-DC switch SK16 (SK19) is switched from 0 to DC; if necessary, readjust potentiometer R126 (R326); Fig. 3.13. tolerance at final check 4 mm.

3.2.4.4. Pre-amplifier (R64, R99, R264, R299)

- Depress Y_A (Y_B) switch SK4 (SK5), AUTO switch SK10 and BEAM SELECTOR switch A SK14 (B SK15)
- Set TIME/cm switch SK2 to 10 ms and TIME/cm potentiometer R2 to CAL
- Set AC-0-DC switch SK16 (SK19) to DC
- Set AMPL switch SK17 (SK18) to .1 V/cm and AMPL potentiometer R4 (R5) to CAL
- Apply a square-wave voltage of 600 $mV_{p\text{-}p}$, 100 Hz, to Y_A (Y_B) input socket BU3 (BU5)
- Check that the pulse top is straight; if necessary, readjust potentiometer R99 (R299), Fig. 3.13.
- Set AMPL switch SK17 (SK18) to 2 mV/cm
- Decrease the input voltage to 12 $mV_{p\text{-}p}$
- Check that the pulse top is straight; if necessary, readjust potentiometer R64 (R264), Fig. 3.14.
- Check that in the ranges 50, 20, 10 and 5 mV/cm of AMPL switch SK17 (SK18) the top is straight; tolerance 1 %

3.2.4.5. Sensitivity (R111, R311)

- Depress Y_A (Y_B) switch SK4 (SK5), AUTO switch SK10, + switch SK8 and BEAM SELECTOR switch A SK14 (B SK15)
- Set TIME/cm switch SK2 to 2 ms and TIME/cm potentiometer R2 to CAL
- Set AC-0-DC switch SK16 (SK19) to DC
- Set AMPL switch SK17 (SK18) to .1 V/cm and AMPL potentiometer R4 (R5) to CAL
- Apply a voltage of exactly 600 $mV_{p\text{-}p}$, 2 kHz, to Y_A (Y_B) input socket BU3 (BU5)
- Check that the trace height is exactly 6 cm; if necessary, readjust potentiometer R111 (R311), Fig. 3.13.
- Check that the control range of AMPL potentiometer R4 (R5) is 1:2.6 to 1:4

3.2.4.6. Input attenuator (C28, C29, C33, C34, C52, C228, C229, C233, C234, C235, C252)

- Depress Y_A (Y_B) switch SK4 (SK5), AUTO switch SK10, + switch SK8 and BEAM SELECTOR switch A SK14 (B SK15)
- Set TIME/cm switch SK2 to 50 μs and TIME/cm potentiometer R2 to CAL
- Set AC-0-DC switch SK16 (SK19) to DC
- Connect a square-wave voltage with an amplitude as indicated in the following table, a repetition rate of 10 kHz and a rise time not exceeding 200 ns to Y_A (Y_B) input socket BU3 (BU5).

– Check that no overshoot is visible (maximum pulse top errors 2 %) and also check the trace height; if necessary, correct the pulse top errors with the aid of the trimmers (Fig. 3.14. page 65) mentioned in the following table

Position AMPL switch SK17 (18)	*Signal to Y_A (Y_B) BU3 (5)*	*Adjust with*	*Trace height*
2 mV/cm	12 mV	C52 (C252)	6 cm + or –2 %
5 mV/cm	30 mV	C52 (C252)	6 cm + or –2 %
10 mV/cm	60 mV	C52 (C252)	6 cm + or –2 %
20 mV/cm	120 mV	C52 (C252)	6 cm + or –2 %
50 mV/cm	300 mV	C52 (C252)	6 cm + or –2 %
.1 V/cm	600 mV	C52 (C252)	6 cm + or –2 %
.2 V/cm	1.2 V	C28 (C228)	6 cm + or –2 %
.5 V/cm	3 V	C28 (C228)	6 cm + or –2 %
1 V/cm	6 V	C28 (C228)	6 cm + or –2 %
2 V/cm	12 V	C33 (C233)	6 cm + or –2 %
5 V/cm	30 V	C33 (C233)	6 cm + or –2 %
10 V/cm	60 V	C33 (C233)	6 cm + or –2 %

– Set AMPL switches SK17 and SK18 to .1 V/cm
– Apply a square-wave voltage of 1.2 $V_{p\text{-}p}$, repetition rate 10 kHz, rise time not exceeding 200 ns, to Y_A input socket BU3 via a 2:1 dummy measuring probe consisting of a 1 MOhm resistor and a 30 pF trimmer in parallel. If higher voltages are available, a 10:1 attenuator probe may be used.
– Adjust the trimmer of the dummy probe for optimum square-wave response
– Apply the input signal via the dummy probe to Y_B input socket BU5
– Check that the top of the displayed pulse is straight; if necessary, readjust trimmer C235 (Fig. 3.14.)
– Connect, via the dummy probe, a square-wave voltage with an amplitude as indicated in the following table, a repetition rate of 10 kHz and a rise time not exceeding 200 ns to Y_A (Y_B) input socket BU3 (BU5)
– Check that neither overshoot nor rounding is visible (maximum pulse top errors 3 %) and also check the trace height; if necessary, correct the pulse top errors with the aid of the trimmers (Fig. 3.14.) mentioned in the following table

Position AMPL switch SK17 (18)	*Signal to 2:1 dummy*	*Adjust with*	*Trace height*
.2 V/cm	2.4 V	C29 (C229)	6 cm + or –2 %
.5 V/cm	6 V	C29 (C229)	6 cm + or –2 %
1 V/cm	12 V	C29 (C229)	6 cm + or –2 %
2 V/cm	24 V	C34 (C234)	6 cm + or –2 %
5 V/cm	60 V	C34 (C234)	6 cm + or –2 %
10 V/cm	60 V	C34 (C234)	3 cm + or –3 %

3.2.4.7. Square-wave response (C901, C1001, C902, C1002, C62, C262, R113, R313)

– Depress Y_A (Y_B) switch SK4 (SK5), AUTO switch SK10 and BEAM SELECTOR switch A SK14 (B SK15)
– Set TIME/cm switch SK2 to .2 μs and TIME/cm potentiometer R2 to CAL
– Set AMPL switch SK17 (SK18) to .1 V/cm and AMPL potentiometer R4 (R5) to CAL
– Set AC-0-DC switch SK16 (SK19) to AC
– Apply a square-wave voltage of 600 mV, repetition rate 1 MHz, rise time 1 ns
– Check the square-wave response. The pulse top errors must not exceed 3 %, maximum permissible overshoot is 2 %; if necessary, readjust trimmers C901 (C1001), C902 (C1002) and C62 (C262) or select a different value for resistor R113 (R313).
– Set AMPL switch SK17 (SK18) to 0.2 mV/cm
– Decrease the input voltage to 12 mV
– Check that the pulse top errors do not exceed 3 % and the overshoot more than 2 %.

3.2.4.8. Bandwidth of the vertical amplifiers

- Depress Y_A (Y_B) switch SK4 (SK5), AUTO switch SK10 and BEAM SELECTOR switch A SK14 (B SK15)
- Set AMPL switch SK17 (SK18) to .1 V/cm and AMPL potentiometer R4 (R5) to CAL
- Check the bandwidth at a trace height of 6 cm in accordance with the following table

Input sine wave on Y_A (Y_B) socket	*Frequency*	*Required trace height*
600 mV_{p-p}	100 kHz	6 cm
600 mV_{p-p}	10 MHz	at least 4,2 cm

3.2.4.9. H.F. deflection and cross-talk

- Depress Y_A (Y_B) switch SK4 (SK5), AUTO switch SK10 and BEAM SELECTOR switches SK14 and SK15
- Set AMPL switch SK17 (SK18) to 50 mV/cm and AMPL potentiometer R4 (R5) to CAL
- Apply a sine-wave voltage of 1,2 V_{p-p}, frequency 3 MHz, to Y_A (Y_B) input socket BU3 (BU5)
- Check that the peaks of the signal can be displayed fairly undistortedly within the graticule, using POSITION potentiometer R11 (R12)
- Set AMPL switches SK17 & SK18 to .1 V/cm and AMPL potentiometers R4 & R5 to CAL
- Apply a sine-wave signal 1,2 V, frequency 3 MHz, to Y_A input socket BU3
- Set AC-0-DC switch SK19 to 0
- Check that the height of the Y_B trace does not exceed 2 mm
- Set AMPL switches SK17 & SK18 to 2 mV/cm and AMPL potentiometers R4 & R5 to CAL
- Apply the input signal to Y_B input socket BU5
- Set AC-0-DC switch SK16 to 0
- Check that the height of the Y_A trace does not exceed 2 mm

INT 1cm@10MHz
EXT 1Vpp@10MHz

3.2.5. TRIGGERING

3.2.5.1. Trigger pre-amplifier (R414)

- Depress Y_A switch SK4, + switch SK8, AC switch SK11 and BEAM SELECTOR switch A SK14
- Set AMPL switch SK17 to .1 V/cm and AMPL potentiometer R4 to CAL
- Set AC-0-DC switch SK16 to AC
- Set TIME/cm switch SK2 to .2 ms and TIME/cm potentiometer R2 to CAL
- Apply a sine-wave signal of 600 mV_{p-p}, frequency 2 kHz, to Y_A input socket BU3
- Set LEVEL potentiometer R3 to such a position that the trace starts at the zero level of the sine-wave
- Depress DC switch SK12
- Check that the trace starts at the same point; if necessary, readjust potentiometer R414 (Fig. 3.12.)
- Decrease the input voltage to 80 mV
- Adjust LEVEL potentiometer R3 for a triggered display
- Check that the display is still triggered when AC switch SK11 is depressed
- Depress BEAM SELECTOR switch B SK15, Y_B switch SK5 and DC switch SK12
- Apply the 80 mV input signal to Y_B socket BU5
- Set AMPL switch SK18 to .1 V/cm and AMPL potentiometer R5 to CAL
- Adjust LEVEL potentiometer R3 for a triggered display
- Depress AC switch SK11; the starting point of the trace must not move more than 4 mm

3.2.5.2. Long-tailed pair circuit (R424)

- Depress Y_A switch SK4, – switch SK9, AUTO switch SK10 and BEAM SELECTOR switch A SK14
- Set AMPL switch SK17 to .1 V/cm and AMPL potentiometer R4 to CAL
- Set TIME/cm switch SK2 to .2 ms and TIME/cm potentiometer R2 to CAL
- Set AC-0-DC switch SK16 to AC
- Apply a sine-wave voltage of 80 mV_{p-p}, frequency 2 kHz, to Y_A socket BU3
- Check that the display remains stationary when LEVEL potentiometer R3 is rotated from fully anti-clockwise to fully clockwise; if necessary readjust potentiometer R424 (Fig. 3.12.)

3.2.5.3. Trigger slope

- Depress Y_A switch SK4, AUTO switch SK10, + switch SK8 and BEAM SELECTOR switch A SK14
- Set TIME/cm switch SK2 to .2 ms and TIME/cm potentiometer R2 to CAL
- Set AMPL switch SK17 to .1 V/cm and AMPL potentiometer R4 to CAL
- Apply a sine-wave signal of 600 mV_{p-p}, frequency 2 kHz, to Y_A input socket BU3
- Adjust LEVEL potentiometer R3 for a stationary display
- Check that the display starts with the positive slope of the signal
- Depress – switch SK9
- Check that the display starts with the negative slope of the signal

3.2.5.4. Level range with external triggering

- Depress EXT switch SK6, AC switch SK11, + switch SK8 and BEAM SELECTOR switch A SK14
- Set AMPL switch SK17 to 10 V/cm and AMPL potentiometer R4 to CAL
- Set TIME/cm switch SK2 to .2 ms and TIME/cm potentiometer R2 to CAL
- Apply a sine-wave voltage of 20 V_{p-p}, frequency 2 kHz, to both TRIGG input socket BU2 and Y_A input socket BU3
- Check that the time-base generator cuts out when LEVEL potentiometer R3 is turned fully anti-clockwise and fully clockwise
- Depress – switch SK9 and repeat the check

3.2.5.5. Level and level range

- Depress Y_A switch SK4, AUTO switch SK10, + switch SK8 and BEAM SELECTOR switch A SK14
- Set AMPL switch SK17 to .1 V/cm and AMPL potentiometer R4 to CAL
- Set TIME/cm switch SK2 to .2 ms and TIME/cm potentiometer R2 to CAL
- Apply a sine-wave voltage of 600 mV_{p-p}, frequency 2 kHz, to Y_A input socket BU3
- Check that the starting point of the trace moves upwards when LEVEL potentiometer R3 is turned clockwise
- Check that the starting point of the trace can be shifted over 5 cm by means of LEVEL potentiometer R3
- Depress AC switch SK11
- Set AMPL switch SK17 to 50 mV/cm
- Check that the time-base generator cuts out when LEVEL potentiometer R3 is turned fully anti-clockwise and fully clockwise
- Set AMPL SK17 switch to 20 mV/cm
- Check that the time-base generator does not cut out when LEVEL potentiometer R3 is turned fully anti-clockwise and fully clockwise

3.2.5.6. Mains triggering

- Depress EXT switch SK6, + switch SK8, AUTO switch SK10 and BEAM SELECTOR switch A SK14
- Set TIME/cm switch SK2 to 20 ms and TIME/cm potentiometer R2 to CAL
- Apply a voltage with the mains frequency to Y_A input socket BU3; trace height 1 cm
- Check that the oscilloscope displays a moving sine wave
- Depress MAINS switch SK7
- Check that the display is stationary

3.2.5.7. Trigger sensitivity

- Set AC-0-DC switches SK16 and SK19 to DC
- Set LEVEL potentiometer R3 to obtain a stationary display
- Set TIME/cm switch SK2 so that a reasonable number of cycles is displayed
- Check the trigger sensitivity in accordance with the following table

Input signal to	*Frequency (sine wave)*	*Depress source switch*	*Depress mode switch*	*Depress BEAM SELECTOR*	*Triggering at*
Y_A BU3	20 Hz	Y_A SK4	AUTO SK10	A SK14	8 mm
	10 MHz				8 mm
	20 Hz		AC SK11		8 mm
	10 Hz				8 mm
	5 Hz		DC SK12		8 mm
	10 MHz				8 mm
Y_B BU5	20 Hz	Y_B SK5	AUTO SK10	B SK15	8 mm
	10 MHz				8 mm
TRIGG BU2 & Y_B BU5	20 Hz	EXT SK6		B SK15	0.8 V
	10 MHz				0.8 V

3.2.5.8. TV Triggering

- Depress Y_A switch SK4, TV switch SK13, + switch SK8 and BEAM SELECTOR switch A SK14
- Set AMPL switch SK17 to .1 V and AMPL potentiometer R4 to CAL
- Apply a television signal of 240 mV, positive video, French system, to Y_A input socket BU3
- Check that the display starts with a frame sync pulse in positions .5 s to 50 μs of TIME/cm switch SK2 and with a line sync pulse in positions 20 μs to .2 μs
- Replace the input signal by a similar signal with negative video information
- Depress — switch SK9
- Set TIME/cm switch SK2 to 50 μs and TIME/cm potentiometer R2 to CAL
- Check that the display starts with a frame sync pulse
- Set TIME/cm switch SK2 to 20 μs
- Check that the display starts with a line sync. pulse

3.2.6. TIME-BASE GENERATOR AND HORIZONTAL AMPLIFIER

3.2.6.1. Time coefficients (R534, R539, R618)

- Depress Y_A switch SK4, + switch SK8, AUTO switch SK10, X MAGN switch SK1 and BEAM SELECTOR switch A SK14
- Set TIME/cm potentiometer R4 to CAL
- Set LEVEL potentiometer R3 to its mid-position
- Set TIME/cm switch SK2 to .5 ms
- Check that the length of the time-base line is 10 to 10,5 cm; if necessary, readjust potentiometer R618 (Fig. 3.12.)
- Set TIME/cm switch SK2 to 20 μs
- Apply a time marker voltage with a repetition time of 20 μs to Y_A input socket BU3
- Check that the 8 centre periods have a total width of 8 cm; if necessary readjust potentiometer R534 (Fig. 3.12.)
- Set TIME/cm switch SK2 to 20 ms
- Change the repetition time of the input signal to 20 ms
- Check that the 8 centre periods have a total width of 8 cm; if necessary, readjust potentiometer R539 (Fig. 3.12.)
- Check that in the other positions of TIME/cm switch SK2 the 8 centre periods have a total width of 8 cm + or — 4 % (the repetition time of the input signal must always correspond to the setting of TIME/cm switch SK2)
- Check that the length of the time-base line is 10 to 12 cm in all positions of TIME/cm switch SK2
- Check that the control range of TIME/cm potentiometer R2 is 1:2,6 to 1:5

3.2.6.2. Magnification and shift (R617)

- Depress Y_A switch SK4, + switch SK8, AUTO switch SK10 and BEAM SELECTOR A SK14
- Set TIME/cm switch SK2 to 20 μs and TIME/cm potentiometer R2 to CAL
- Apply a time marker voltage with a repetition time of 20 μs to Y_A input socket BU3
- Pull X MAGN switch SK1 to x5
- Shift every cycle on to the screen by means of X POSITION potentiometer R1 and check that each cycle has a width of 5 cm + or −2 %; if necessary, readjust potentiometer R617 (Fig. 3.12.)
- Check that with X POSITION potentiometer R1 the beginning and the end of the time-base line can be displayed within the graticule
- Set TIME/cm switch SK2 to .2 μs
- Change the repetition time of the input signal to .2 μs
- Check that the widths of all periods are equal within + or −2 %

3.2.7. MAINS VOLTAGE FLUCTUATIONS

- Vary the mains voltage + and −10 % with respect to the nominal mains voltage as indicated by the voltage adapter
- Check that the vertical and horizontal deflection are not affected and that the brightness does not change

3.2.8. BEAM SELECTION

- Depress AUTO switch SK10
- Set TIME/cm switch SK2 to 1 ms
- Set AMPL switches SK17 and SK18 to .1 V/cm
- Depress BEAM SELECTOR switch A SK14
- Check that only the channel Y_A time-base line is visible
- Release BEAM SELECTOR switch A SK14 and depress B SK15
- Check that only the channel Y_B time-base line is visible

3.2.9. X-Y OPERATION (R601)

- Depress AUTO switch SK10, X MAGN SK1 and BEAM SELECTOR SWITCHES A SK14 and B SK15
- Set TIME/cm switch SK2 to 5 ms
- Set AMPL switch SK17 to .1 V/cm and AMPL potentiometer R4 to CAL
- Set POSITION potentiometer R11 to its mid-position
- Set AC-0-DC switch SK16 to AC
- Set X POSITION potentiometer R1 to such a position that the time-base lines start at the beginning of the measuring graticule
- Centre the Y_B time-base line by means of POSITION potentiometer R12
- Set TIME/cm switch SK2 to position X via Y_A
- Check that the spot is displayed in the centre of the screen; tolerance + or − 5 mm
- Check that no Y_A trace is visible, also when POSITION potentiometer R11 is rotated
- Apply a sine-wave voltage of 800 mV_{p-p}, frequency 2 kHz, to Y_A input socket BU3
- Centre the trace by means of X POSITION potentiometer R1
- Check that the trace width is 8 cm + or −5 %; if necessary, readjust potentiometer R601 (Fig. 3.12.)
- Increase the frequency of the input voltage to 1 MHz
- Check that the trace width is at least 6 cm

3.2.10. Z MODULATION

- Depress Y_A switch SK4, + switch SK8, AUTO switch SK10 and BEAM SELECTOR switch A SK14
- Apply a positive-going square-wave voltage of 20 V, repetition rate 100 Hz, to Z MOD socket BU7
- Apply a signal which is synchronous with the former square-wave voltage to Y_A input socket BU3
- Check that the trace is blanked during the positive pulse

3.2.11. OUTPUT SOCKETS

3.2.11.1. Calibration voltage on CAL socket BU1 (R761)

- Check, with the aid of an accurate peak-peak voltmeter, that the voltage on CAL socket BU1 has a value of 600 mV_{p-p} + or − 0,7 %; if necessary, readjust potentiometer R761 (Fig. 3.12.)
- Check that the pulse does not show overshoot and that the repetition frequency is 2 kHz + or −20 %

3.2.11.2. Time-base voltage on TB OUT socket BU6

- Depress AUTO switch SK10
- Set TIME/cm switch SK2 to 2 ms
- Check that the amplitude of the sawtooth voltage on TB OUT socket BU6 is 6 V + or − 20 %

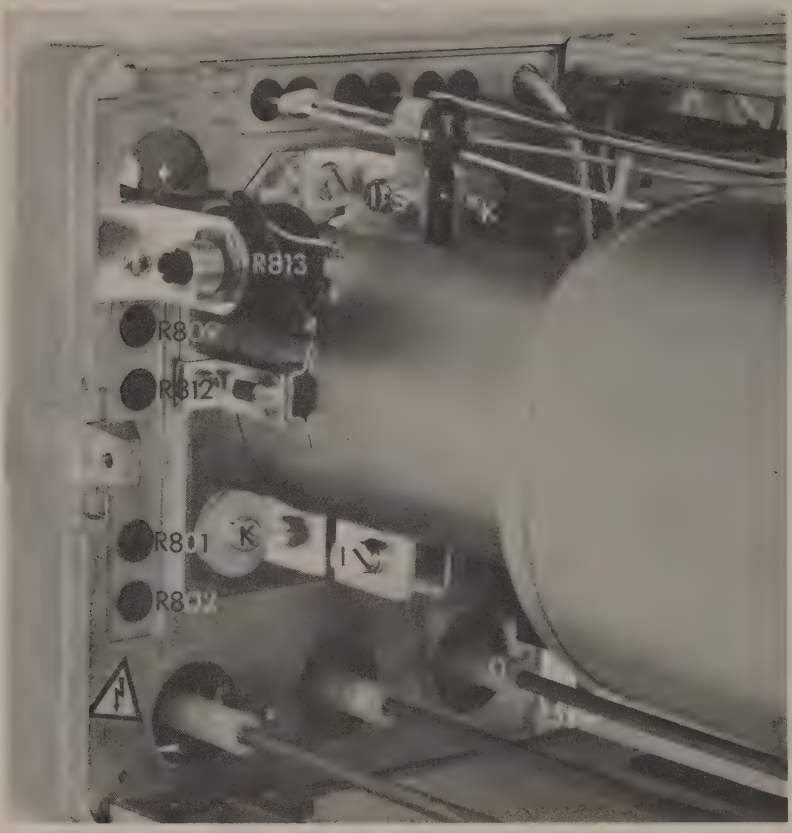


Fig. 3.11. Adjusting and dismantling

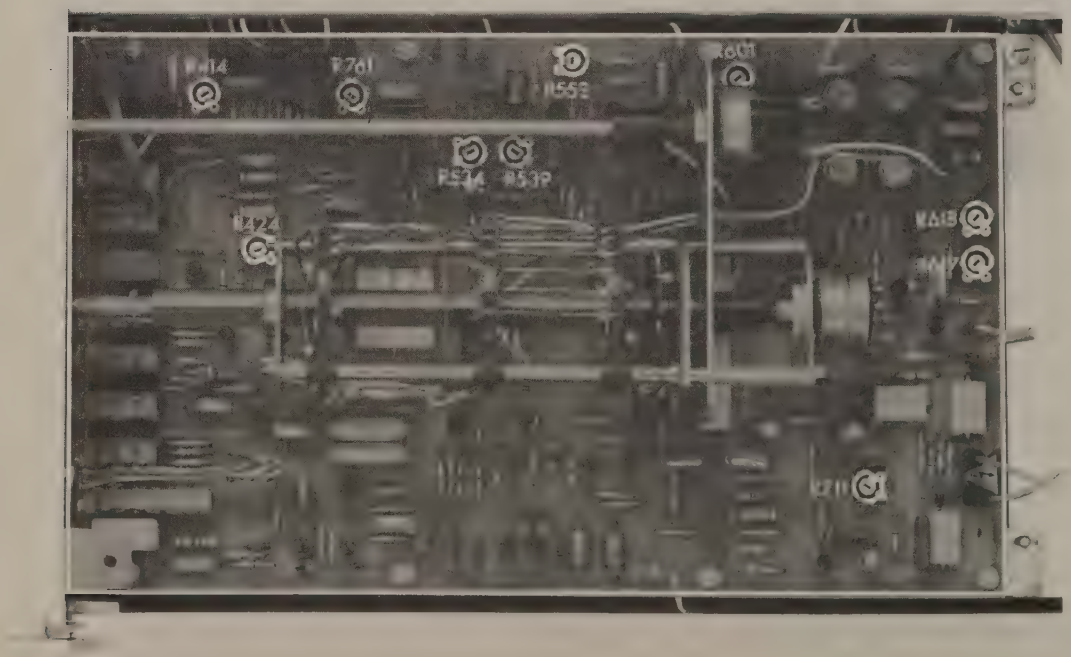


Fig. 3.12. Adjusting

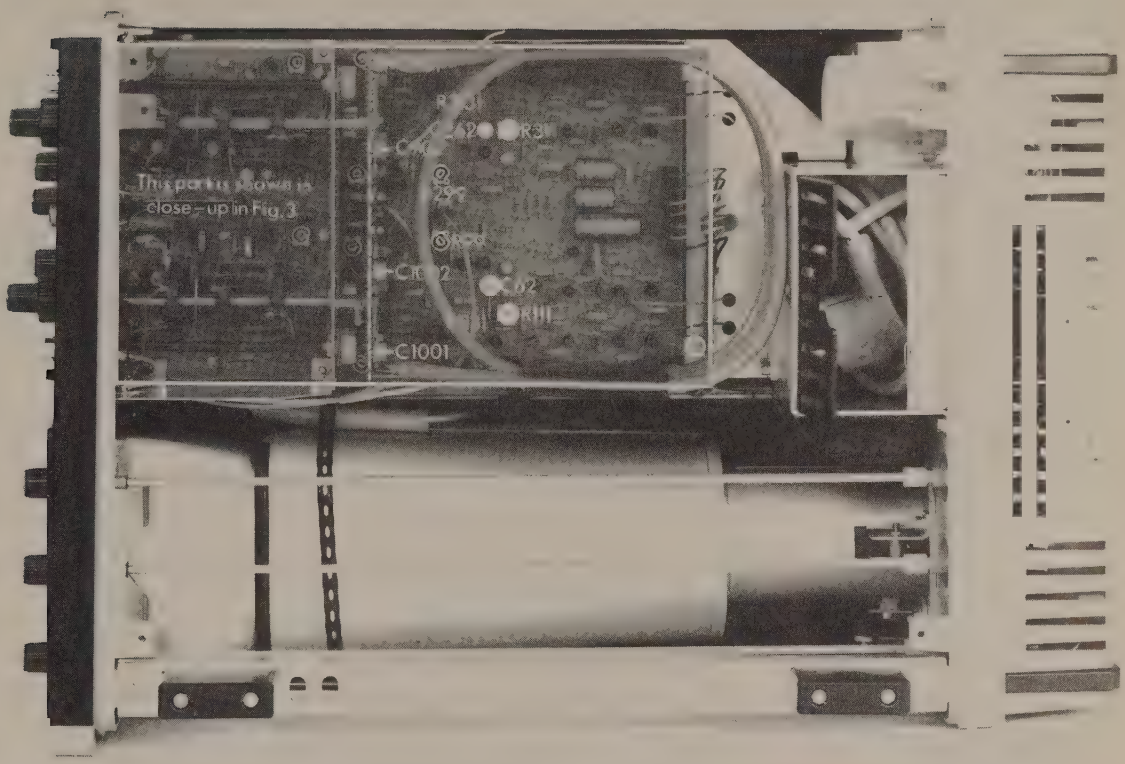


Fig. 3.13. Adjusting and dismantling

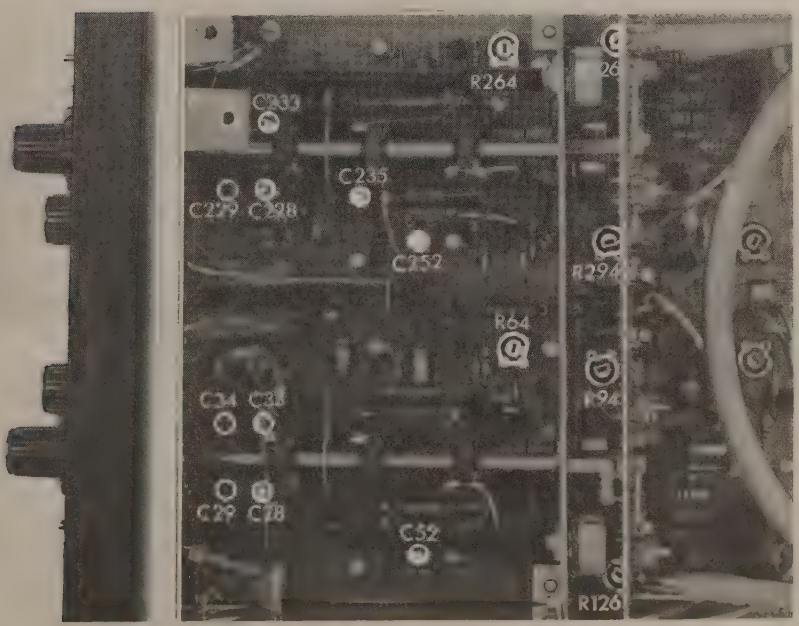


Fig. 3.14. Adjusting

3.3. Dismantling the instrument

3.3.1. WARNING

The opening of parts of the instrument or the removal of covers is likely to expose live conductors.
The instrument must, therefore, be disconnected from all voltage sources before any opening of parts or removal of covers is started.
If the E.H.T. connector of the c.r.t. is disconnected, both connector and c.r.t. must be discharged immediately by shortening them to earth.

3.3.2. KNOBS

3.3.2.1. Knobs of Y POSITION potentiometers R11 & R12 and AC-0-DC switches SK16 & SK19

These knobs can be pulled off the shaft.

3.3.2.2. Single knobs (Fig. 3.15.)

– Remove cap A
– Slacken screw B
– Pull the knob off the shaft

3.3.2.3. Double knobs (Fig. 3.15.)

– Remove cap A
– Slacken screw B
– Pull the inner knob off the shaft
– Slacken nut C
– Pull the outer knob off the shaft

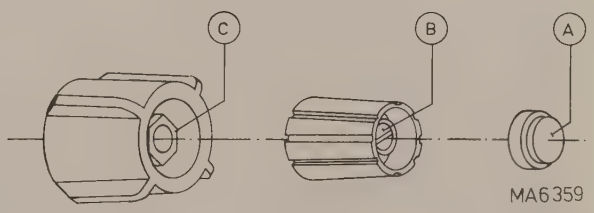


Fig. 3.15. Knobs

3.3.3. BEZEL

– Slightly lift the lower part of the bezel and swivel it upwards
– Subsequently mask, contrast filter and measuring graticule can be removed

3.3.4. CABINET PLATES

Top and bottom cabinet plates can be taken off after removing four screws for each plate.

3.3.5. GRATICULE ILLUMINATION LAMPS

– Remove the bezel with graticule, filter and mask
– Squeeze lamp holder flanges slightly inwards and push the lamp holder out of the frame. Be careful not to mechanically load the soldering tags of the lamp holder, as they break easily.
The bulb is then accessible.

To refit:

– Push the lamp holder back in its opening until the hooks on the flanges snap over the frame

IMPORTANT: Take care that the sign on the lamp holder points towards the top of the oscilloscope in order to avoid short circuits (Fig. 3.18.).

3.3.6. PILOT LAMP

The pilot lamp is removed in the same way as the graticule illumination lamps.

3.3.7. TEXT PLATE OF C.R.T. CONTROLS

– Remove the bezel with graticule filter and mask
– Remove the knobs of the ILLUM, FOCUS and INTENS potentiometers
– Remove the fixing nuts around the shafts of the ILLUM and INTENS potentiometers

3.3.8. TIME-BASE UNIT

– Remove the X POSITION, TIME/cm and LEVEL knobs
– Unplug all connectors on the time-base board (a few connectors can be unplugged at the vertical amplifier board)
– Remove two screws A (Fig. 3.16.)
– Remove two screws B (Fig. 3.16.)
– Remove two screws and nuts C (Fig. 3.16.)
– Lift the unit out of the instrument
– When refitting the unit, make sure that the screening plate between time-base and vertical amplifier unit clicks into place over the cross bars of the frame.

Note: In order to maintain the mechanical strength of the oscilloscope, the time-base unit and the vertical amplifier unit must not be removed at the same time.

3.3.9. VERTICAL AMPLIFIER UNIT

– Remove the AC-0-DC, AMPL and POSITION knobs
– Set the AC-0-DC switches SK16 & 19 to 0
– Remove all connectors on the amplifier board
– Remove two screws D (Fig. 3.17.)
– Remove two screws E (Fig. 3.13.)
– Remove two screws C (Fig. 3.16.)
– Lift the unit out of the instrument
– When refitting the unit, make sure that the AC-0-DC switches are in 0 position and that the screening plate between time-base and amplifier unit clicks into place over the cross bars of the frame

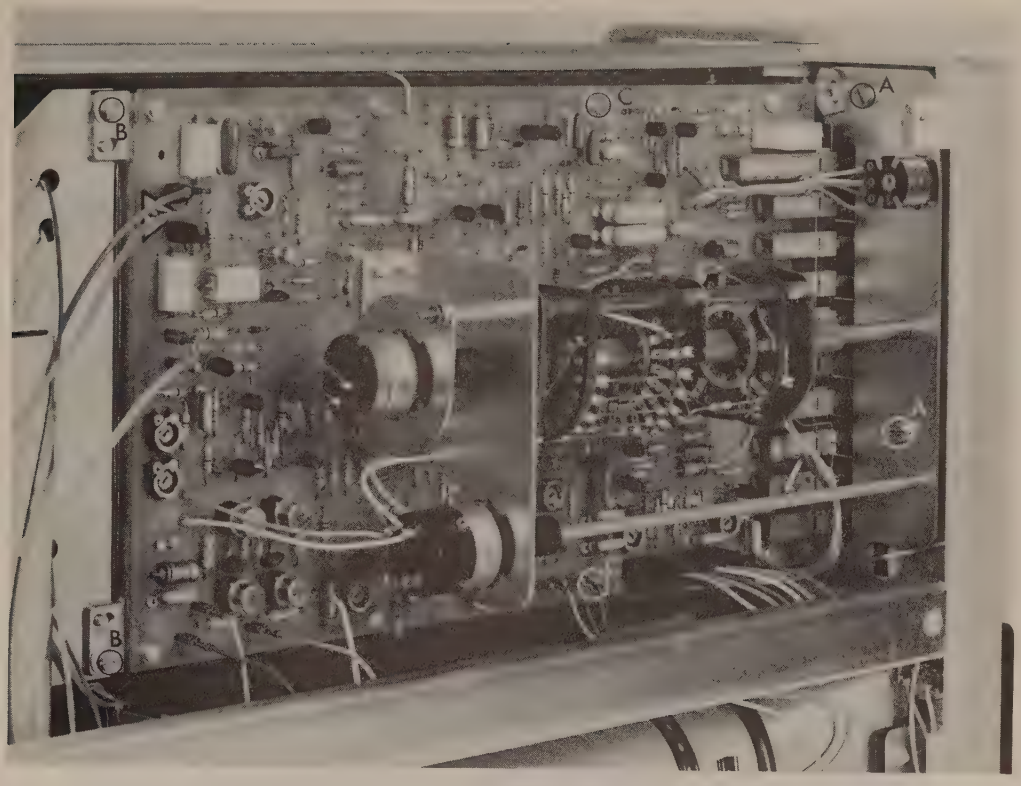


Fig. 3.16. Dismantling

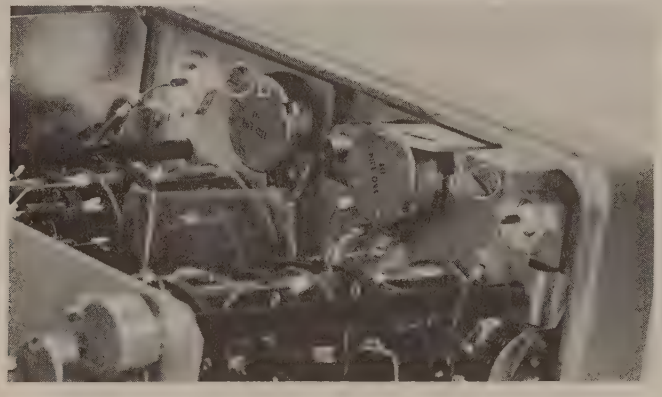


Fig. 3.17. Dismantling

3.3.10. MAIN TEXT PLATE

- Remove all knobs except those of the c.r.t. controls
- Set the AC-0-DC switches SK16 & 19 to 0
- Remove the time-base unit
- Remove the earth connector BU4
- Remove the retaining clips of the bearings for the X POSITION and the LEVEL potentiometer, and the bearings themselves
- Unplug the connector of the CAL socket
- Remove the retaining clip of the CAL socket, and the CAL socket itself
- Take the text plate out of the front panel

3.3.11. CATHODE-RAY TUBE

– Remove the bezel with graticule, filter and mask
– Loosen the 2 adjusting screws F (Fig. 3.18.)
– Remove the EHT connector (discharge connectors and c.r.t. immediately by shortening them to earth)
– Unplug both wires G (Fig. 3.18)
– Slacken screws I (Fig. 3.11.)
– Push the c.r.t. out of the front side of the oscilloscope (be careful not to damage the soldering tags on the trace rotation coil).
– Remove the valve holder
– Refitting of the c.r.t. is done in the reverse order (take due care that the sleeve H fits properly around the screening tube), but some mechanical adjustments can be made:
– Slacken the two screws K (Fig. 3.11.) and move the end of the tube in such a way that the tube face is flush with the front of the oscilloscope.
– Retighten screws K (Fig. 3.11.)
– Adjust screws F (Fig. 3.18.) in such a way that the tube face fits optimally in the mask
– Secure the screws F by means of the nuts F

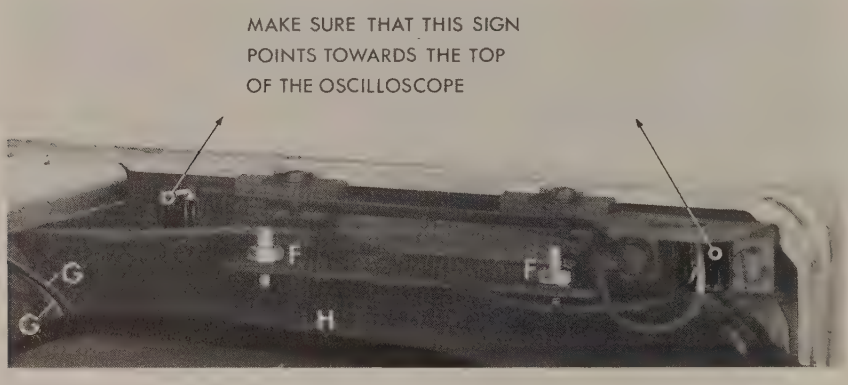


Fig. 3.18. Dismantling

3.3.12. MAINS TRANSFORMER

– Remove the rear cover (three screws X, Fig. 2.1.)
– Unsolder and unplug the relevant connections (two plugs and the mains cable connections)
– Remove the four screws L (when refitting the transformer do not forget the earth wire of the voltage quintupler), Fig. 3.19.
– Take the transformer with voltage adapter and capacitor out of the instrument

3.3.13. POWER SUPPLY BOARD

If only the components on the board must be made accessible, proceed as follows:
– Remove the rear cover (three screws X, Fig. 2.1.)
– Remove the rear panel with the sockets, by removing the three screws and spacers M (Fig. 3.10)
– Unplug all connectors on the power supply board
– If necessary, remove the valve holder of the c.r.t.
– Remove the five screws N (Fig. 3.10.)
– Swivel the board out of the instrument (Fig. 3.20.)

If the wiring board must be replaced, also unsolder the remaining connection wires along the sides of the board, including the connection of the mains cable to the ILLUM potentiometer and the connections to the valve holder of the c.r.t.

Note: When replacing the board, make sure that the shafts of the ILLUM, FOCUS and INTENS potentiometers fit properly in the coupling bushes 0 (Fig. 3.11.).

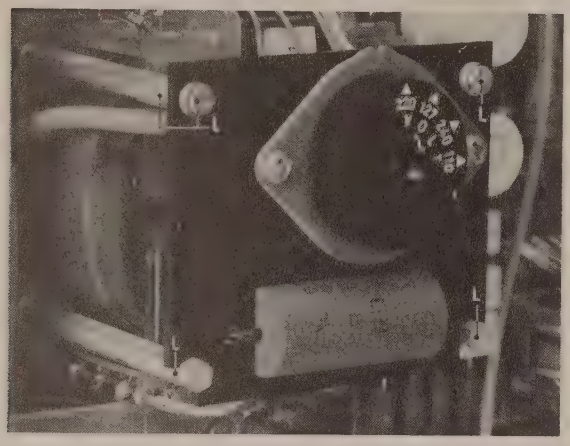


Fig. 3.19. Dismantling

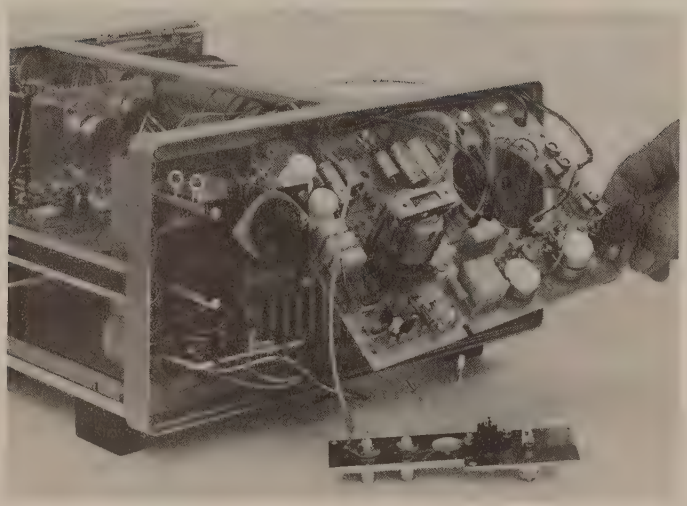


Fig. 3.20. Supply unit swiveled out

3.3.14. VOLTAGE QUINTUPLER

- Remove the rear cover (three screws X, Fig. 2.1.)
- Remove the E.H.T. plug of the c.r.t. and discharge the connector and c.r.t. immediately by shortening them to earth.
- Unsolder the E.H.T. lead at point P on the supply unit (Fig. 3.10.)
- Unsolder the earth wire of the quintupler
- Slightly squeeze the quintupler flanges inside the cable compartment together and pull the quintupler out

3.3.15. REPLACING A SWITCH OF THE TRIGG PUSH-BUTTON UNIT

- Remove the time-base unit in accordance with section 3.3.8.
- Straighten the 4 retaining lugs of the relevant switch as shown in Fig. 3.21.
- Break the body of the relevant switch by means of a pair of pliers and remove the pieces. The soldering pins are then accessible.
- Remove the soldering pins and clean the holes in the printed-wiring board (e.g. with a suction soldering iron)
- Solder the new switch onto the printed-wiring board
- Bend the 4 retaining lugs back to their original positions

N.B.: The Y_A and + switch are not soldered, so it is sufficient to just straighten the 4 retaining lugs to remove them.

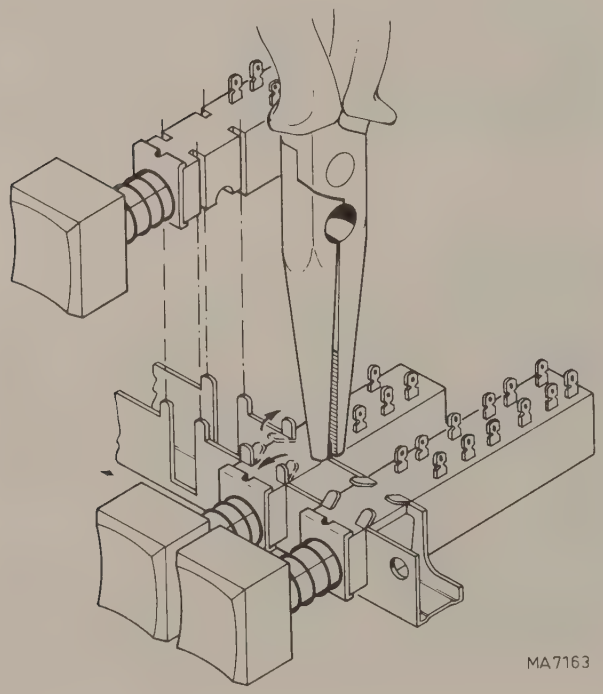


Fig. 3.21. Replacing a push-button switch

3.4. Information for assistence in fault-finding

3.4.1. MAINS TRANSFORMER DATA

The available unloaded voltage tappings and the number of turns per winding are listed in the circuit diagram in the form of a table.

3.4.2. VOLTAGES AND WAVEFORMS IN THE INSTRUMENT

The d.c. voltage levels at the electrodes of the transistors and the voltage waveforms in the time-base generator are shown at the relevant points on the circuit diagram.

The waveforms have been measured under the following conditions:
- Input signal on Y_A socket BU3: 2 kHz sine-wave voltage for 6 cm deflection
- LEVEL potentiometer R3 in mid-position
- TIME/cm switch SK2 to .2 ms and X MAGN switch SK1 to x1
- Y_A, + and AUTO push-buttons SK4, SK8 and SK10 depressed
- AMPL switch SK17 to 1 V/cm

The voltage values are typical and may slightly differ per instrument.

3.4.3. REMARK

In case of a defect it is always possible to apply to the world wide PHILIPS Service Organization.
When the instrument is to be sent to a PHILIPS Service Workshop for repair, the following points should be observed:
- Attach a label with your name and address to the instrument
- Give a complete description of the faults found
- Use the original packing, or, if this is no longer available, carefully pack the instrument in a wooden crate or box
- Send the instrument to the address obtained after consultation with the local PHILIPS Organization.

3.5. Information concerning accessories

3.5.1. FRONT COVER

This is a plastic cover to protect the oscilloscope front during transport. The cover contains storage space for two passive probes and two BNC to 4 mm adapters. This storage space is accessible after the cover plate has been removed. To this end, bend the lugs A (Fig. 3.22.) slightly outwards and lift off the cover plate.

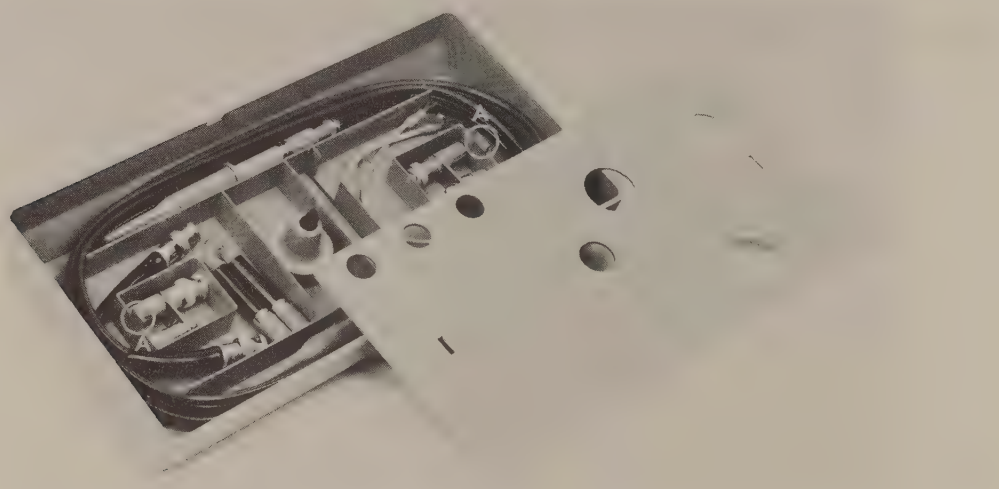


Fig. 3.22. Front cover

3.5.2. ADAPTER PM 9051

This is an adapter to make a BNC socket suitable for the connection of two 4 mm banana plugs.

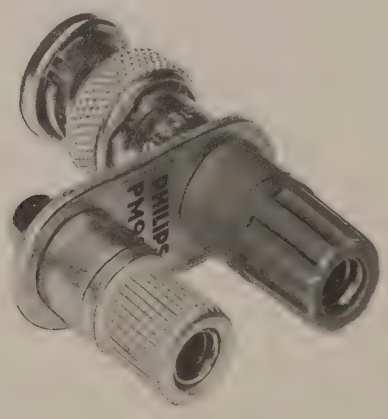


Fig. 3.23. Adapter PM 9051

3.5.3. ATTENUATOR PROBE SETS PM 9326 and PM 9327 (Fig. 3.24.)

These passive probe sets are equal but for the length of the probe cable, which is 1,15 m for the PM 9326 and 2 m for the PM 9327.

The sets consist of:

1 probe cable	Fig. 3.24. item 1
1 earth lead 15 cm	Fig. 3.24. item 2
1 earth lead 30 cm	Fig. 3.24. item 3
1 measuring probe 1:1 (black)	Fig. 3.24. item 4
1 test pin	Fig. 3.24. item 5
1 test hook	Fig. 3.24. item 6
1 attenuator probe 1:10 (grey)	Fig. 3.24. item 7
1 test clip	Fig. 3.24. item 8
1 box	Fig. 3.24. item 9

The measuring probe and the earth lead can be simply pulled from the cable. The test clip, test pin and test hook are screwed on to the measuring probe.

For ordering numbers of these parts, see list 3.6.3.1.

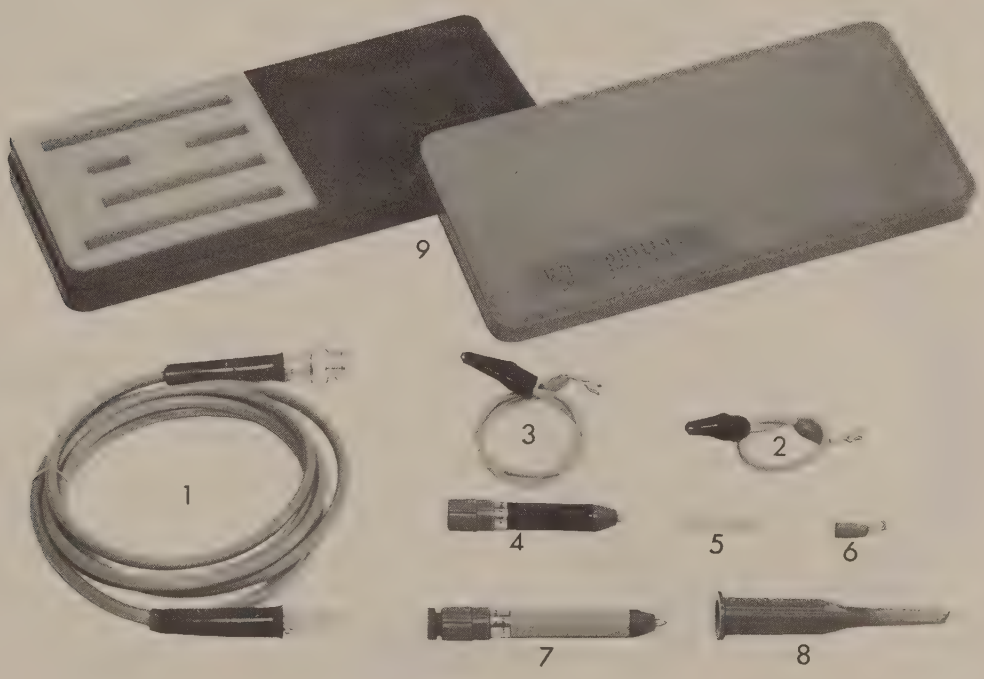


Fig. 3.24. Attenuator probe set PM 9326 (PM 9327)

3.5.3.1. Technical data

Attenuation	1:10 ±3 %
Input impedance	10 MOhm//10 pF
Max. permissible input voltage	1000 V_{p-p}

Maximum d.c. component 500 V with the blocking capacitor included into the circuit.

3.5.3.2. Adjustment (Fig. 3.25.)

- Unscrew the probe locking nut by turning it anit-clockwise
- Rotate the probe body to change the capacitance while watching the display for the desired waveform
- When compensation is completed, carefully turn the locking nut clockwise, to lock it without disturbing the adjustment

The attenuator probe causes distortion if it has not been properly adjusted.

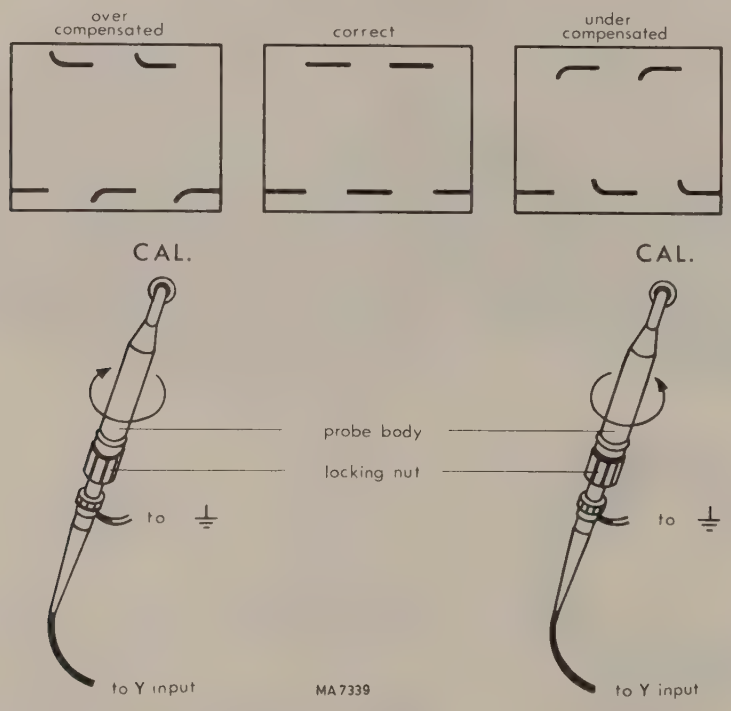


Fig. 3.25. Adjusting an attenuator probe

3.5.4. ATTENUATOR PROBE SETS PM 9336 and PM 9336L

The PM 9336 is a 10x attenuator probe, designed for oscilloscopes up to 25 MHz, having a BNC input jack and 10 to 35 pF input capacitance, paralleled by 1 MΩ. The PM 9336L is a similar probe with a cable length of 2.5 m.

The set consist of:

1 probe assembly	Fig. 3.26. item 1
5 soldering terminals	Fig. 3.26. item 2
1 test hook	Fig. 3.26. item 3
2 spare test hook sleeves	Fig. 3.26. item 4
1 protective cap	Fig. 3.26. item 5
1 probe holder	Fig. 3.26. item 6
2 probe tips	Fig. 3.26. item 7
1 earthing cord	Fig. 3.26. item 8
1 box	item 9

For ordering numbers of these parts, see list 3.6.3.2.

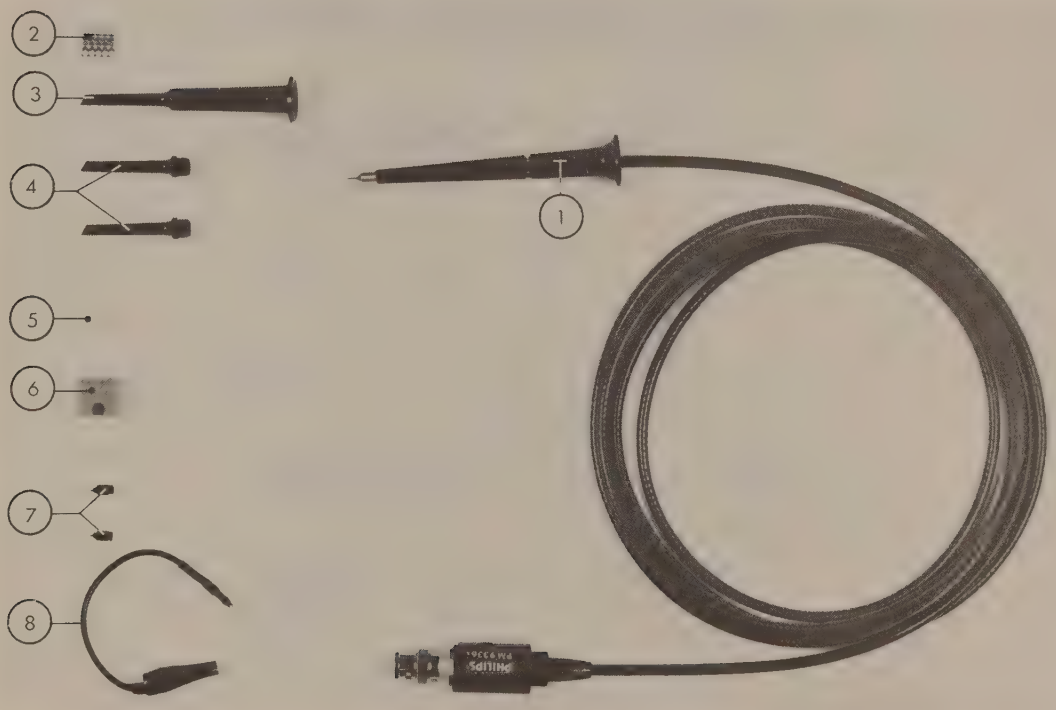


Fig. 3.26. Attenuator probe set PM 9336 (PM 9336L)

3.5.4.1. Technical data

Attenuation	1:10 ±3 %
Input resistance	PM 9336 10 MOhm ±2 % PM 9336L 10 MOhm ±2 %
Input capacitance	PM 9336 11 pF ±1 pF PM 9336L 14 pF ±1 pF
Maximum allowable input voltage	500 V (D.C. + A.C. peak)

3.5.4.2. Adjustment

The measuring probe has been adjusted and checked by the factory. However, to match the probe to your oscilloscope, the following manipulation is necessary.
Connect the measuring pin to socket CAL of the oscilloscope.
A trimmer can be adjusted through a hole in the compensation box to obtain optimum square-wave response.

See the following examples

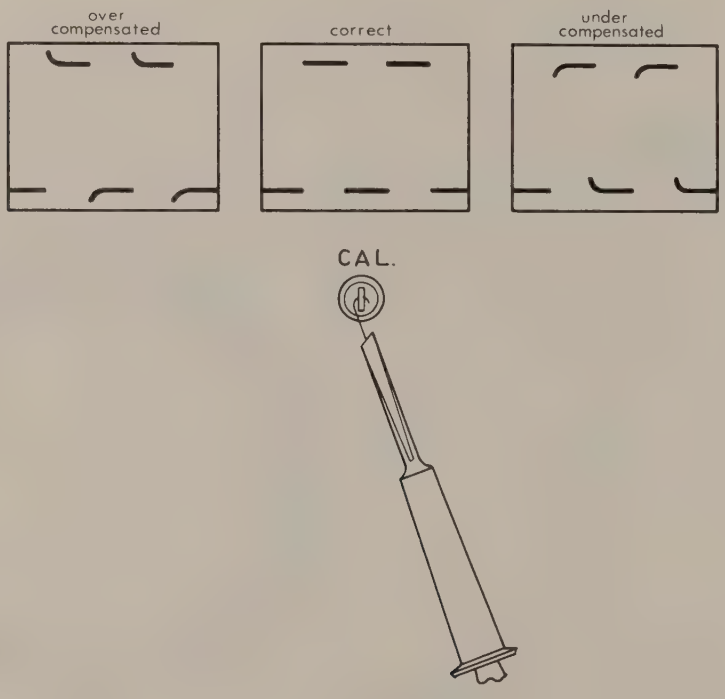


Fig. 3.27. Probe compensation

3.5.5. 1:1 PROBE SET PM 9335

The PM 9335 is a passive probe without signal attenuation for use with oscilloscope, counters and voltmeters having a high input impedance and a BNC input socket.
The cable design is such that the reflections due to the instrument's capacitive load are absorbed.
The useful frequency range of this probe is restricted to d.c. and l.f. applications (up to 10 MHz).

The set consist of:

1 test hook	Fig. 3.28. item 1
2 spare test hook sleeves	Fig. 3.28. item 2
2 spare probe tips	Fig. 3.28. item 3
1 protective cap	Fig. 3.28. item 4
1 earthing lead	Fig. 3.28. item 5
1 probe holder	Fig. 3.28. item 6
1 probe assembly	Fig. 3.28. item 7
1 box	item 8

For ordering numbers of these parts, see list 3.6.3.3.

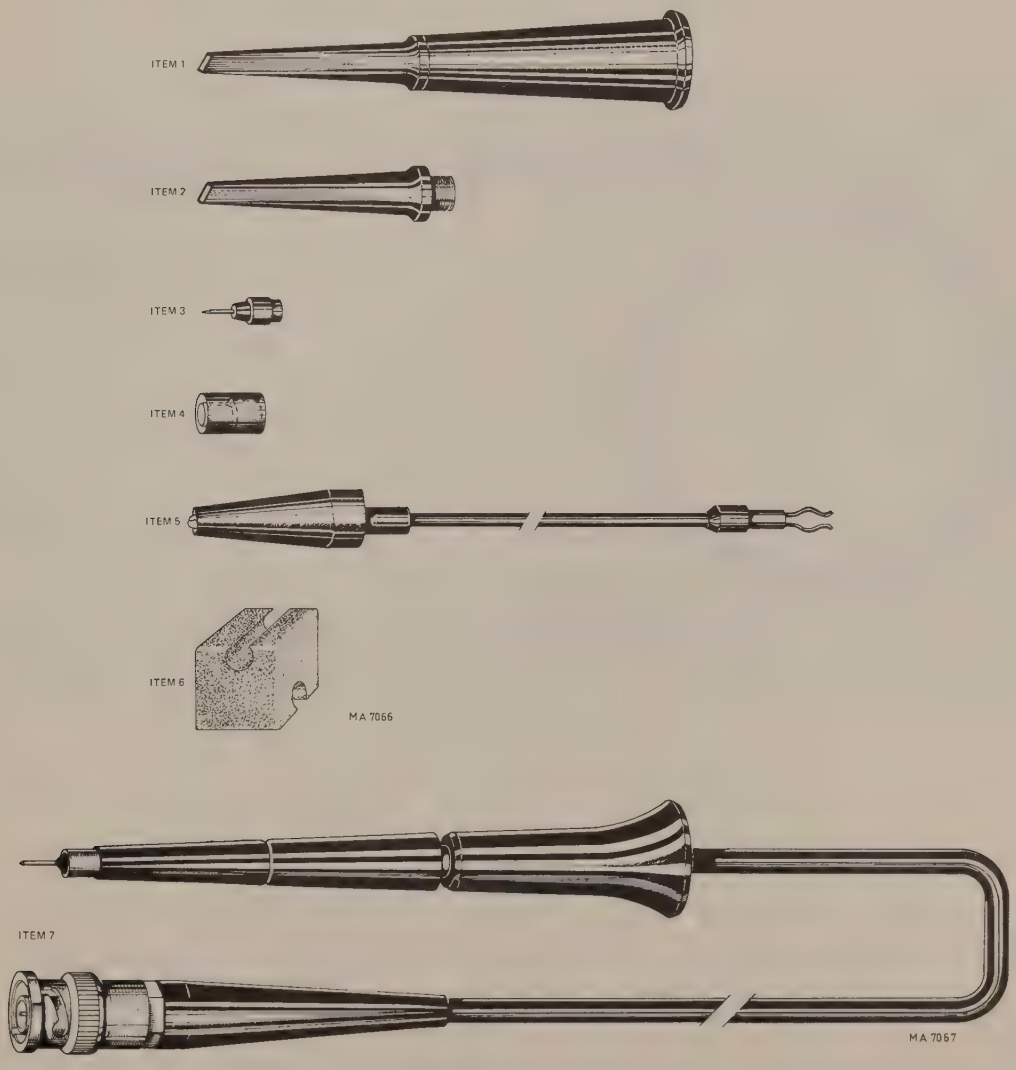


Fig. 3.28. Probe set PM 9335

3.5.5.1. Technical data

Attenuation	1:1
Input resistance	1 MOhm
Input capacitance	45 ± 5 pF + input cap. of measuring instrument

Max. allowable input voltage

D.C.	500 V
A.C. peak-to-peak	500 V divided by frequencies in MHz or 500 V whichever is smaller
A.C. peak + D.C.	500 V

Dimensions	**L**	**W**	**H**
probe body	105		mm
cable	1.5		m
box	230	104	24 mm

3.5.6. 2 kV ATTENUATOR PROBE SET PM 9358

The PM 9358 is a 100x attenuator probe which can handle signals up to 2 kV_{rms}. The probe has been designed for use with oscilloscopes having a bandwidth up to 150 MHz, a BNC input jack and an input impedance of 1 MΩ paralleled by 14 to 21 pF.

The set consist of:

1 probe assembly	Fig. 3.29. item 1
5 soldering terminals	Fig. 3.29. item 2
1 test hook	Fig. 3.29. item 3
1 spare test hook sleeve	Fig. 3.29. item 4
1 protective cap	Fig. 3.29. item 5
1 insulating cap	Fig. 3.29. item 6
1 probe holder	Fig. 3.29. item 7
2 spare test pins	Fig. 3.29. item 8
1 earthing cord	Fig. 3.29. item 9
1 box	item 10

For ordering numbers of these parts, see list 3.6.3.4.

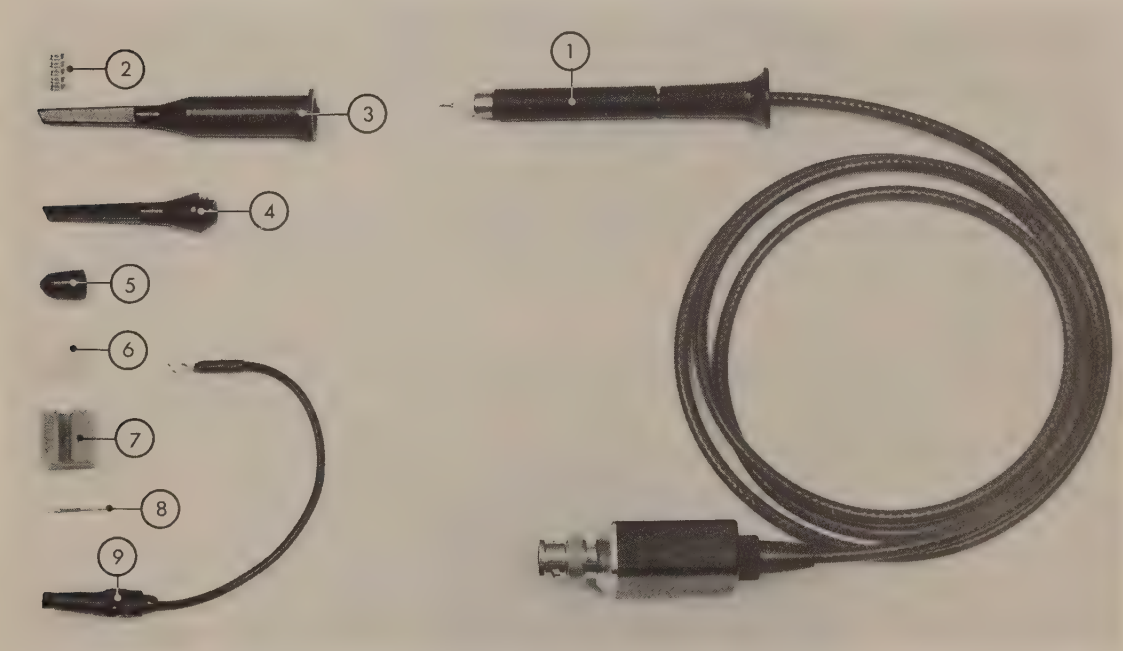


Fig. 3.29. Attenuator probe set PM 9358

3.5.6.1. Technical data

Attenuation		1:100 ±2 %
Input resistance		20 MOhm ±3 %
Input capacitance		2 pF ± 0.3 pF
Max. allowable voltage DC or AC_{rms}		
Continuous	2 kV	
Under pulsed conditions	2 kV	Duty cycle 50 - 100 % dv/dt ⩽ 1000 V/ns Pulse rep. frequency ⩽ 1 MHz
	3 kV	Duty cycle 25 - 50 % dv/dt ⩽ 500 V/ns Pulse rep. frequency ⩽ 1 MHz Max. pulse duration 100 ms
	4 kV	Duty cycle 0 - 25 % dv/dt ⩽ 200 V/ns Pulse rep. frequency ⩽ 1 MHz Max. pulse duration 20 ms
Sine waves continuous	5,6 kV_{p-p}	For frequencies up to 1 MHz

3.5.6.2. Adjustment

The measuring probe has been adjusted and checked by the factory. However, to match the probe to your oscilloscope, the following manipulation is necessary. Connect the measuring pin to socket CAL of the oscilloscope. A trimmer can be adjusted through a hole in the compensation box to obtain optimum square-wave response.

See the following examples:

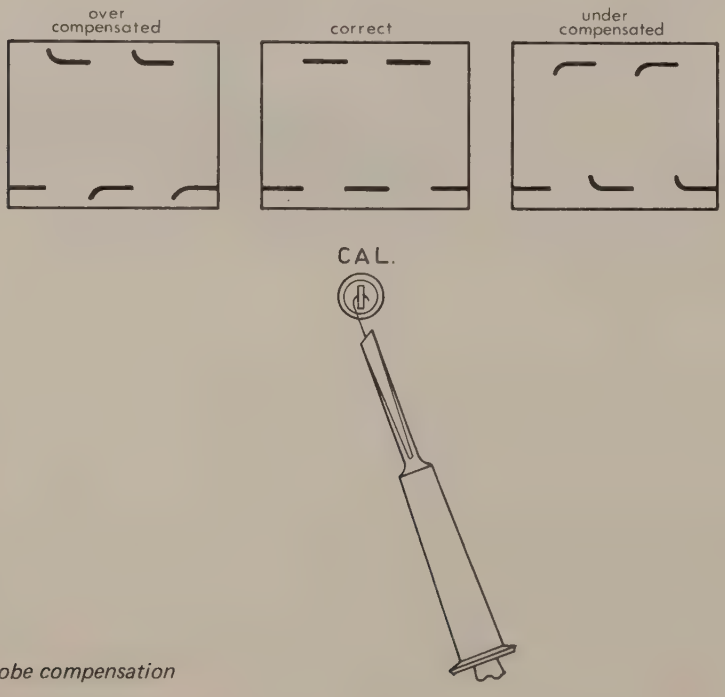


Fig. 3.30. Probe compensation

3.5.7. SET OF EAGLE CLIPS PM 9333

PM 9333 Set of eagle clips especially designed to probe difficult to reach signal sources, all types of wrapped wiring etc.

Each set contains:

10 eagle clips fitting the probes PM 9335, PM 9336 and PM 9336L
10 adapter pieces fitting the probes PM 9326 and PM 9327
10 adapter pieces fitting the micro-miniature probe PM 9352

Fig. 3.31. Adapter set PM 9333

3.5.8. MULTI-PURPOSE CAMERA PM 9380 (Fig. 3.26.)

Camera PM 9380 has been designed to photograph oscilloscope displays in a quick and simple way.
It incorporates the Polaroid instant photographic process which has the advantage that you can see the picture a few moments after you took it.

Fig. 3.32. Multi-purpose camera PM 9380

3.5.9. ADAPTER PM 9379 (Fig. 3.27)

This adapter forms the connection between camera PM 9380 and oscilloscope PM 3232. The dimensions of the adapter are such, that the camera is automatically focussed when the camera-adapter combination is held against the front of the oscilloscope.

NOTE

Together with this adapter, supplementary lens PM 9373 must be used.

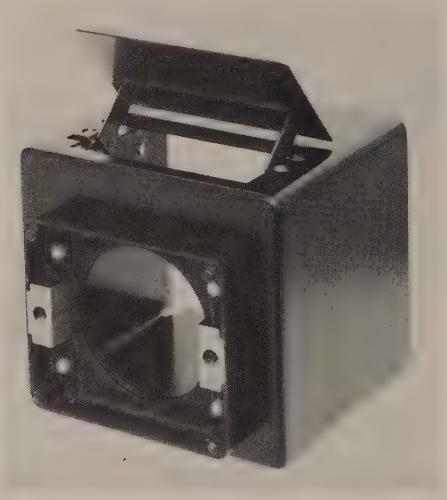


Fig. 3.33. Adapter PM 9379

3.6. List of parts

3.6.1. MECHANICAL PARTS

Item	*Fig.*	*Qty*	*Ordering number*	*Description*
1	3.34	1	5322 268 14052	Calibration terminal BU1 compl.
2	3.34	1	5322 268 10031	Calibration contact pin BU1
3	3.34	1	5322 325 84011	Grommet for BU1
4	3.34	1	5322 492 60799	Spring for BU1
5	3.34	1	5322 532 54198	Insulating ring for BU1
6	3.34	8	5322 414 34119	Control knob (R1, R2, R3, R4, R5, R8, R9, R10)
7	3.34	7	5322 414 74014	Cover for control knob (grey)
8	3.34	3	5322 414 74016	Cover for control knob (blue)
9	3.34	3	5322 414 34081	Switch knob (SK3, SK17, SK18)
10	3.34	7	5322 276 14101	Push-button switch (SK4...SK12)
11	3.34	3	5322 276 14102	Push-button switch (SK13)
12	3.34	10	5322 414 24846	Knob for SK4...SK13
13	3.34	1	5322 455 84028	Text plate, front
14	3.34	5	5322 267 10004	BNC socket (BU2, BU3, BU5, BU6, BU7)
15	3.34	5	5322 506 14001	Nut for BNC socket
16	3.34	3	5322 532 24319	Padding ring for BU2, BU3, BU5
17	3.34	2	5322 276 14103	Push-button switch (SK14, SK15)
18	3.34	2	5322 414 24845	Knob for SK14, SK15
19	3.34	2	5322 277 14047	Lever switch (SK16, SK19)
20	3.34	1	5322 498 ~~54039~~ 54046	Carrying handle
21	3.34-35	2	5322 500 14152	Screw
22	3.34	1	5322 462 54067	Tilting-bracket
23	3.34	2	5322 462 44067	Hinge for tilting-bracket
24	3.34-36	4	5322 462 40252	Foot
25	3.34	1	5322 535 80523	Earthing terminal (BU4)
26	3.34	1	5322 505 14178	Nut for BU4
27	3.34	2	5322 414 34108	Control knob (R11, R12)
28	3.34	2	5322 492 64377	Clamping spring for R11, R12
29	3.34	1	5322 381 10152	Lens
30	3.34	1	5322 455 84025	Text plate
31	3.34	1	5322 450 14001	Graticule
32	3.34	1	5322 480 34034	Contrast filter (green)
33	3.34	1	5322 480 34043	Contrast filter (amber)
34	3.34	1	5322 451 34001	Mask
35	3.34	1	5322 451 34002	Bezel
36	3.35	1	5322 526 14009	Cylindrical magnet
37	3.35	1	5322 255 70159	Valve socket for CRT
38	3.35	1	5322 462 44127	Rubber sleeve for CRT
39	3.35	1	5322 466 85168	Earthing terminal
40	3.35	1	5322 405 94046	Clamp for earthing terminal
41	3.35	1	5322 267 40127	Socket 6 cont. (BU8)
42	3.35	1	5322 455 84026	Text plate, rear
43	3.35	1	4822 272 10079	Voltage adaptor

Item	*Fig.*	*Qty.*	*Ordering number*	*Description*
44	3.35	6	5322 255 40038	Transistor socket
45	3.35-36	75	5322 255 40089	Transistor socket
46	3.35-36	3	5322 255 24015	Lamp holder for La1, La2, La3
47	3.36	2	5322 532 34079	Coupling piece for R4, R5
48	3.36	2	5322 462 70715	Plastic cap
49	3.36	2	5322 255 40106	S Clip (insulated)
49	3.36	2	5322 255 44053	S Clip (non-insulated)
50	3.36	1	5322 321 10071	Mains flex
51	3.36	3	5322 532 24321	Coupling piece for R8, R9, R10
52	3.37	1	5322 447 94091	Front cover
53	3.37	1	5322 414 34086	Key
54	3.37	1	5322 492 54152	Compression spring
55	3.37	1	5322 455 84009	Plate
56	3.36	1	5322 216 54075	High tension unit
57	3.36	1	5322 218 64043	Printed wiring board of vertical amplifier unit, complete with components (incl. att. switches, delay line unit and delay line)
58	3.36	1	5322 216 54091	Delay line unit
59	3.35	1	5322 218 64034	Printed wiring board of time-base unit, complete with components (incl. time-base switch)
60	3.35	1	5322 216 54088	Printed wiring board of power supply unit, complete with components
61	3.36	2	5322 105 34008	Attenuator switch, complete (SK17, SK18)
62	3.35	1	5322 105 34009	Time-base switch, complete (SK2)

3.6.1.1. Miscellaneous parts

Item	*Ordering number*	*Description*
B1	5322 131 24024	C.R.T. type E14-100GM
B1	5322 131 24015	C.R.T. type E14-100GH
LA1	5322 134 40268	Lamp 28 V, 40 mA (Type 387)
LA2	5322 134 40268	Lamp 28 V, 40 mA (Type 387)
LA3	5322 134 40268	Lamp 28 V, 40 mA (Type 387)
VL1	5322 252 20007	Thermal fuse (125 ^{o}C)
VL802	4822 253 30022	Fuse, 1.25 A delayed action
T801	5322 146 24087	Mains transformer

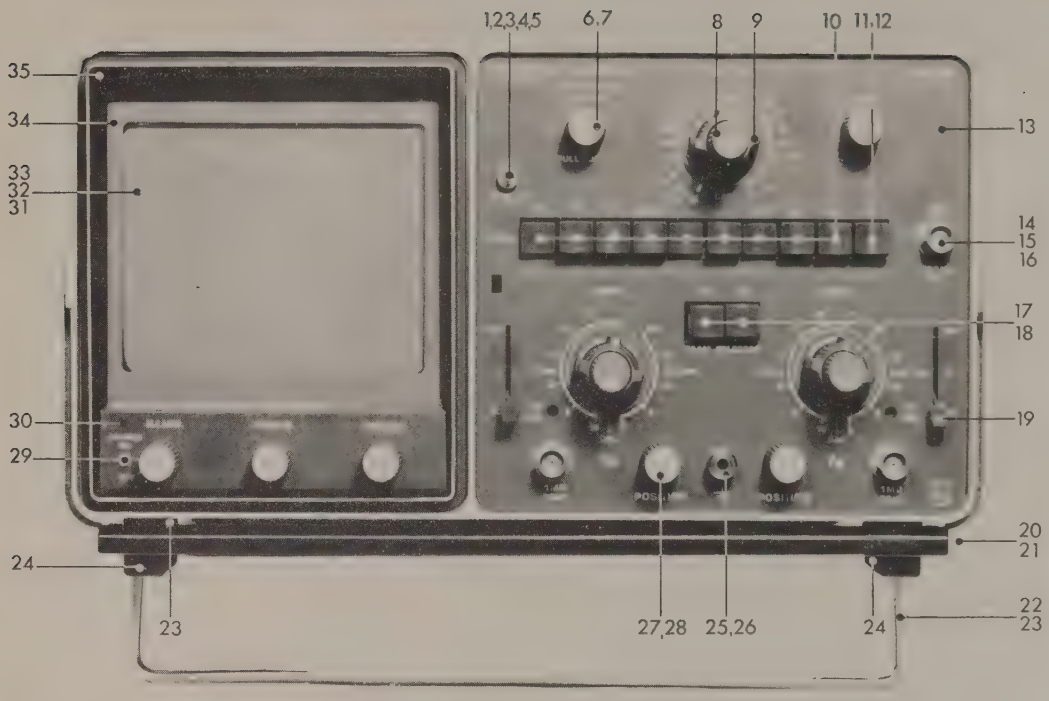


Fig. 3.34. Front view showing item numbers

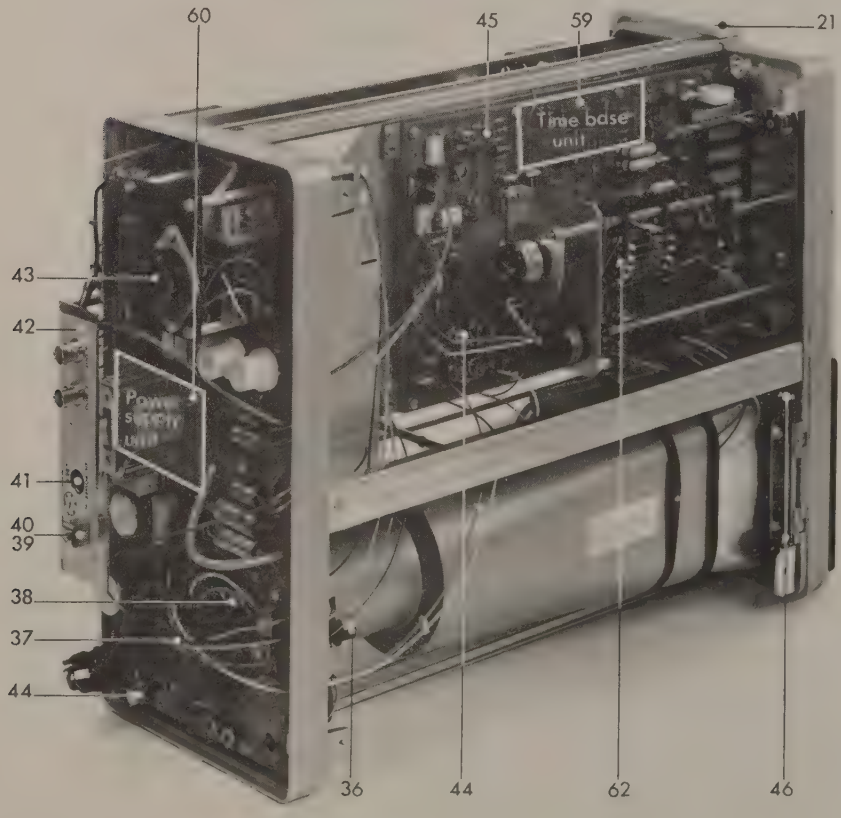
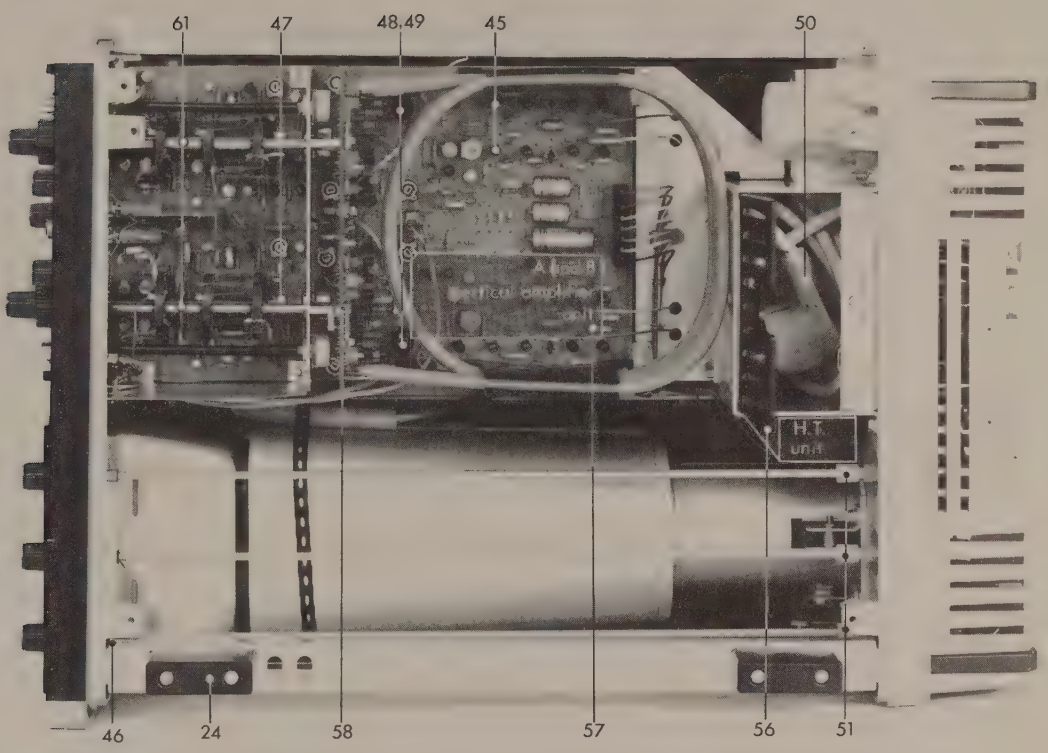
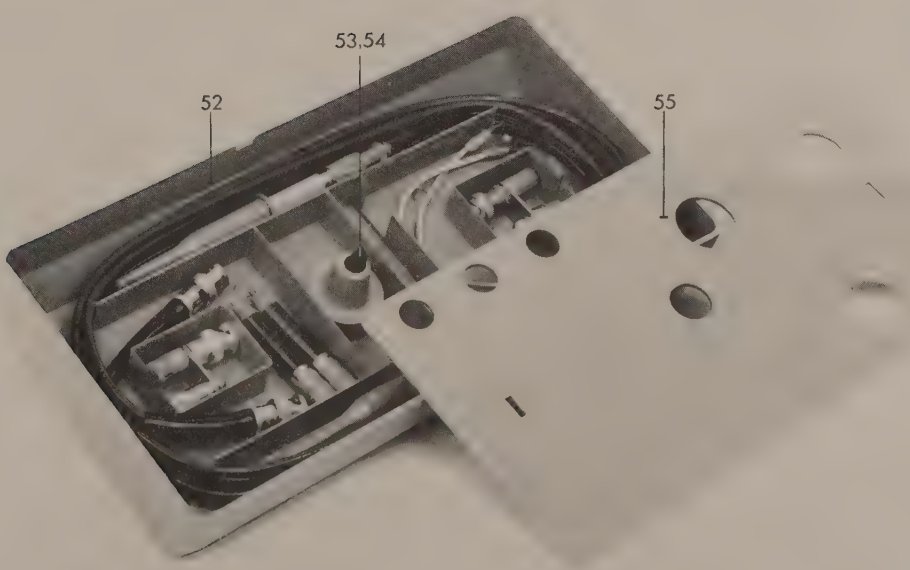


Fig. 3.35. Top and rear view showing item numbers



g. 3.36. Bottom view showing item numbers



g. 3.37. Front cover showing item numbers

3.6.2. ELECTRICAL PARTS

3.6.2.1. Capacitors

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C26	4822 121 40145	100N	10	630	POLYESTER FOIL
C27	4822 122 31197	15P	2	500	CERAMIC PLATE
C28	5322 125 50049	10P		300	TRIMMER
C29	5322 125 50049	10P		300	TRIMMER
C31	4822 120 31074	56P	5	500	POLYSTYRENE
C32	4822 122 31187	2,7P	0,25P	500	CERAMIC PLATE
C33	5322 125 50049	10P		300	TRIMMER
C34	5322 125 50049	10P		300	TRIMMER
C35	4822 120 11043	3,9P	0,5	500	CERAMIC
C36	4822 121 50418	390P	5	250	POLYSTYRENE FOIL
C37	4822 121 41161	100N	10	250	POLYESTER FOIL
C50	4822 122 31081	100P	2	63	CERAMIC PLATE
C51	4822 120 11072	47P	5	500	CERAMIC
C52	5322 125 50051	18P		300	TRIMMER
C53	4822 122 31067	33P	2	100	CERAMIC PLATE
C54	4822 121 41152	47N	10	250	POLYESTER FOIL
C55	4822 121 41152	47N	10	250	POLYESTER FOIL
C56	4822 122 31172	180P	10	100	CERAMIC PLATE
C57	4822 124 20468	33M		16	ELECTROLYTIC
C58	4822 124 20453	68M		6,3	ELECTROLYTIC
C59	4822 121 40313	10N	10	250	POLYESTER FOIL
C60	4822 121 41152	47N	10	250	POLYESTER FOIL
C61	4822 124 20468	33M		16	ELECTROLYTIC
C62	4822 125 50045	22P		100	TRIMMER
C63	4822 121 41152	47N	10	250	POLYESTER FOIL
C64	4822 122 31178	680P	10	100	CERAMIC PLATE
C66	4822 122 31178	680P	10	100	CERAMIC PLATE
C67	4822 122 31072	47P	2	63	CERAMIC PLATE
C68	4822 122 31175	1N	10	100	CERAMIC PLATE
C69	4822 122 31081	100P	2	63	CERAMIC PLATE
C73	4822 122 31215	0,68P	0,25P	63	CERAMIC PLATE
C74	4822 122 31215	0,68P	0,25P	63	CERAMIC PLATE
C76	4822 122 31215	0,68P	0,25P	63	CERAMIC PLATE
C77	4822 122 31215	0,68P	0,25P	63	CERAMIC PLATE
C78	4822 122 31215	0,68P	0,25P	63	CERAMIC PLATE
C79	4822 122 31215	0,68P	0,25P	63	CERAMIC PLATE
C80	4822 121 41152	47N	10	250	POLYESTER FOIL
C81	4822 121 41152	47N	10	250	POLYESTER FOIL
C82	4822 124 20473	220		16	ELECTROLYTIC
C83	4822 121 40104	150N	10	250	POLYESTER FOIL
C84	4822 121 41152	47N	10	250	POLYESTER FOIL
C226	4822 121 40145	100N	10	630	POLYESTER FOIL
C227	4822 122 31197	15N	2	500	CERAMIC PLATE
C228	5322 125 50049	10P		300	TRIMMER
C229	5322 125 50049	10P		300	TRIMMER
C231	4822 120 31074	56P	5	500	POLYSTYRENE
C232	4822 122 31187	2,7P	0,25P	500	CERAMIC PLATE
C233	5322 125 50049	10P		300	TRIMMER
C234	5322 125 50049	10P		300	TRIMMER
C235	5322 125 50049	10P		300	TRIMMER
C236	4822 121 50418	390P	5	250	POLYSTYRENE FOIL
C237	4822 121 41161	100N	10	250	POLYESTER FOIL
C250	4822 122 31074	56P	2	100	CERAMIC PLATE
C251	4822 120 11072	47P	5	500	CERAMIC
C252	5322 125 50051	18P		300	TRIMMER
C253	4822 122 31067	33P	2	100	CERAMIC PLATE
C256	4822 122 31172	180P	10	100	CERAMIC PLATE
C257	4822 124 20468	33M		16	ELECTROLYTIC
C258	4822 124 20453	68M		6,3	ELECTROLYTIC
C259	4822 121 40313	10N	10	250	POLYESTER FOIL
C261	4822 124 20468	33M		16	ELECTROLYTIC
C262	4822 125 50045	22P		100	TRIMMER
C263	4822 121 41152	47N	10	250	POLYESTER FOIL
C264	4822 122 31178	680P	10	100	CERAMIC PLATE
C266	4822 122 31178	680P	10	100	CERAMIC PLATE
C267	4822 122 31072	47P	2	63	CERAMIC PLATE
C273	4822 122 31215	0,68P	0,25P	63	CERAMIC PLATE
C274	4822 122 31215	0,68P	0,25P	63	CERAMIC PLATE

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C276	4822 122 31215	0,68P	C,25P	63	CERAMIC PLATE
C277	4822 122 31215	0,68P	C,25P	63	CERAMIC PLATE
C278	4822 122 31215	0,68P	C,25P	63	CERAMIC PLATE
C279	4822 122 31215	0,68P	C,25P	63	CERAMIC PLATE
C281	4822 121 41152	47N	10	250	POLYESTER FOIL
C282	4822 124 20473	220M		16	ELECTROLYTIC
C283	4822 124 20527	470M		25	ELECTROLYTIC
C284	4822 121 40313	10N	10	250	POLYESTER FOIL
C285	4822 124 20467	15M		16	ELECTROLYTIC
C400	4822 122 30045	27P	2	63	CERAMIC PLATE
C401	4822 120 11027	1P	C,25P	500	CERAMIC
C402	4822 121 41152	47N	10	250	POLYESTER FOIL
C403	4822 121 41152	47N	10	250	POLYESTER FOIL
C404	4822 122 30114	2,2N	10	100	CERAMIC PLATE
C405	4822 121 41152	47N	10	250	POLYESTER FOIL
C406	4822 121 40197	1M	10	100	POLYESTER FOIL
C407	4822 121 41152	47N	10	250	POLYESTER FOIL
C408	4822 121 40186	470N	10	250	POLYESTER FOIL
C409	4822 121 40186	470N	10	250	POLYESTER FOIL
C410	4822 124 20466	4,7M		16	ELECTROLYTIC
C411	4822 124 20585	0,47M		63	ELECTROLYTIC
C413	4822 121 40313	10N	10	250	POLYESTER FOIL
C414	4822 121 41152	47N	10	250	POLYESTER FOIL
C415	4822 121 41152	47N	10	250	POLYESTER FOIL
C416	4822 124 20467	15M		16	ELECTROLYTIC
C417	4822 121 41152	47N	10	250	POLYESTER FOIL
C418	4822 122 31168	270P	10	100	CERAMIC PLATE
C501	4822 122 31067	33P	2	100	CERAMIC PLATE
C502	4822 122 31067	33P	2	100	CERAMIC PLATE
C503	4822 122 31067	33P	2	100	CERAMIC PLATE
C504	4822 122 31058	15P	2	100	CERAMIC PLATE
C505	4822 121 41152	47N	10	250	POLYESTER FOIL
C506	4822 124 20466	4,7M		16	ELECTROLYTIC
C507	5322 122 30115	560P	10	100	CERAMIC PLATE
C508	4822 121 41152	47N	10	250	POLYESTER FOIL
C509	4822 122 31175	1N	10	100	CERAMIC PLATE
C510	4822 122 31063	22P	2	100	CERAMIC PLATE
C511	4822 122 31221	1,5N	10	100	CERAMIC PLATE
C513	4822 124 20468	33M		16	ELECTROLYTIC
C514	4822 124 20468	33M		16	ELECTROLYTIC
C516	4822 124 20468	33M		16	ELECTROLYTIC
C521	4822 121 40266	4,7M	10	100	POLYESTER FOIL
C522	4822 121 50564	510P	1	250	POLYSTYRENE FOIL
C523	5322 121 50373	5,6N	1	63	POLYSTYRENE FOIL
C524	4822 124 20492	1,5M		63	ELECTROLYTIC
C526	4822 121 50424	1N	5	125	POLYSTYRENE FOIL
C601	4822 122 30092	180P	2	100	CERAMIC PLATE
C602	4822 122 31175	1N	10	100	CERAMIC PLATE
C603	4822 122 31052	8,2P	C,25P	63	CERAMIC PLATE
C604	4822 121 41152	47N	10	250	POLYESTER FOIL
C606	4822 124 20468	33M		16	ELECTROLYTIC
C607	4822 121 41152	47N	10	250	POLYESTER FOIL
C608	4822 124 20467	15M		16	ELECTROLYTIC
C609	4822 124 20467	15M		16	ELECTROLYTIC
C702	4822 124 20467	15M		16	ELECTROLYTIC
C703	4822 121 41138	15N	10	250	POLYESTER FOIL
C704	4822 121 40104	150N	10	250	POLYESTER FOIL
C706	4822 121 40253	1N	10	1600	POLYESTER FOIL
C707	4822 121 40253	1N	10	1600	POLYESTER FOIL
C708	4822 122 31058	15P	2	63	CERAMIC PLATE
C709	4822 121 40253	1N	10	1600	POLYESTER FOIL
C710	4822 121 41152	47N	10	250	POLYESTER FOIL
C750	4822 121 41147	33N	10	250	POLYESTER FOIL
C751	4822 121 41143	22N	10	250	POLYESTER FOIL
C752	4822 121 41161	100N	10	250	POLYESTER FOIL
C753	4822 124 20475	10M		25	ELECTROLYTIC
C754	4822 124 20467	15M		16	ELECTROLYTIC
C756	4822 122 31175	1N	10	100	CERAMIC PLATE
C801	4822 121 41152	47N			POLYESTER FOIL
C802	4822 121 41134	10N	10	250	POLYESTER FOIL

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
C803	4822 121 40196	22N	10	630	POLYESTER FOIL
C804	4822 121 41152	47N	10	1600	POLYESTER FOIL
C805	4822 121 41152	47N	10	250	POLYESTER FOIL
C807	4822 121 41152	47N	10	250	POLYESTER FOIL
C809	4822 121 40197	1M	10	100	POLYESTER FOIL
C810	5322 121 44109	100N	20	250	POLYESTER FOIL
C811	4822 121 40197	1M	10	100	POLYESTER FOIL
C812	4822 121 40197	1M	10	100	POLYESTER FOIL
C813	4822 124 20492	1,5M		63	ELECTROLYTIC
C814	4822 124 20492	1,5M		63	ELECTROLYTIC
C815	4822 121 41161	100N	10	250	POLYESTER FOIL
C816	4822 121 41161	100N	10	250	POLYESTER FOIL
C817	4822 124 70226	2350MX2		40	ELECTROLYTIC
C818	4822 124 20453	68M		6,3	ELECTROLYTIC
C819	4822 124 20453	68M		6,3	ELECTROLYTIC
C820	4822 121 41161	100N	10	250	POLYESTER FOIL
C821	4822 121 41134	10N	10	630	POLYESTER FOIL
C822	5322 122 54004	470P	20	4000	CERAMIC DISK
C823	5322 122 54004	470P	20	4000	CERAMIC DISK
C824	5322 122 54004	470P	20	4000	CERAMIC DISK
C825	4822 124 20462	100M		10	ELECTROLYTIC
C826	4822 121 40196	22N	10	1600	POLYESTER FOIL
C827	4822 121 40196	22N	10	1600	POLYESTER FOIL
C828	4822 124 20313	10M		200	ELECTROLYTIC
C829	4822 124 20305	32M		100	ELECTROLYTIC
C831	4822 124 20527	470M		25	ELECTROLYTIC
C832	4822 124 20468	33M		16	ELECTROLYTIC
C833	4822 124 20473	220M		16	ELECTROLYTIC
C834	4822 124 20468	33M		16	ELECTROLYTIC
C836	4822 124 20473	220M		16	ELECTROLYTIC
C837	5322 122 54004	470P	20	4000	CERAMIC DISK
C838	5322 122 54004	470P	20	4000	CERAMIC DISK
C901	4822 125 50045	22P		100	TRIMMER
C902	4822 125 50045	22P		100	TRIMMER
C903	4822 122 31173	220P	10	100	CERAMIC PLATE
C904	4822 121 40313	10N	10	250	POLYESTER FOIL
C906	4822 122 31177	470P	10	100	CERAMIC PLATE
C907	4822 124 20483	6,8M		40	ELECTROLYTIC
C908	4822 121 41152	47N	10	250	POLYESTER FOIL
C1001	4822 125 50045	22P		100	TRIMMER
C1002	4822 125 50045	22P		100	TRIMMER
C1003	4822 122 31173	220P	10	100	CERAMIC PLATE
C1004	4822 121 40313	10N	10	250	POLYESTER FOIL
C1006	4822 122 31177	470P	10	100	CERAMIC PLATE
C1007	4822 120 11054	10P	5	500	CERAMIC

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION

3.6.2.2. Diodes

GR53	5322 130 34037	BAV45
GR54	5322 130 30759	BZX79-C5V6
GR56	5322 130 30766	BZX79-C6V2
GR57	5322 130 30766	BZX79-C6V2
GR58	5322 130 30766	BZX79-C6V2
GR253	5322 130 34037	BAV45
GR254	5322 130 30759	BZX79-C5V6
GR257	5322 130 30766	BZX79-C6V2
GR401	5322 130 40182	BAX13
GR402	5322 130 40182	BAX13
GR403	5322 130 30759	BZX79-C5V6
GR404	5322 130 30231	AAZ13
GR406	5322 130 30231	AAZ13
GR407	5322 130 40182	BAX13
GR408	5322 130 34069	BZX79-C12
GR409	5322 130 40182	BAX13
GR501	5322 130 30231	AAZ13
GR502	5322 130 40182	BAX13
GR503	5322 130 40182	BAX13
GR504	5322 130 40182	BAX13
GR506	5322 130 30273	BAX16
GR701	5322 130 40182	BAX13
GR702	5322 130 30273	BAX16
GR703	5322 130 34039	BZX79-C24
GR751	5322 130 34167	BZX79-B6V2
GR801	5322 130 34076	BZX79-C18
GR802	5322 130 34168	BZX79-C47
GR803	5322 130 30259	BY127
GR804	5322 130 30259	BY127
GR806	5322 130 30259	BY127
GR807	5322 130 30259	BY127
GR808	5322 130 30759	BZX79-C5V6
GR809	5322 130 34049	BZX75-C2V1
GR810	5322 130 30424	BAX13
GR811	5322 130 30759	BZX79-C5V6
GR812	5322 130 30424	BAX12
GR813	5322 130 34136	BY187
GR814	5322 130 34136	BY187
GR816	5322 130 34136	BY187
GR817	5322 130 34136	BY187
GR818	5322 130 30256	BA148
GR819	5322 130 30605	BAX17
GR820	5322 130 30256	BA148
GR821	5322 130 30424	BAX12
GR822	5322 130 30424	BAX12
GR823	5322 130 30424	BAX12
GR824	5322 130 30424	BAX12
GR826	5322 130 30424	BAX12
GR827	5322 130 30424	BAX12
GR828	5322 130 30605	BAX17
GR829	5322 130 30256	BA148
GR831	5322 130 30259	BY127
GR832	5322 130 34136	BY187
GR833	5322 130 34136	BY187
GR901	5322 130 34174	BZX79-B4V7
GR1001	5322 130 34174	BZX79-B4V7

3.6.2.3. Coils

L401	5322 158 10308	COIL 68MUH
L801	5322 156 34005	COIL TYPE R6
L802	5322 148 84007	CONVERTER-COIL
L803	4822 157 50308	CHOKE 140MUH
L804	4822 157 50308	CHOKE 140MUH
L805	5322 158 10308	COIL 68MUH

3.6.2.4. Lamps

LA1	5322 134 40268	TYPE 387 28V 40MA
LA2	5322 134 40268	TYPE 387 28V 40MA
LA3	5322 134 40268	TYPE 387 28V 40MA

3.6.2.5. Resistors

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R1	5322 101 64003	2,2K	20	0,25W	CARBON POTM LIN + SWITCH
R2	5322 101 44005	10K	20	0,25W	CARBON POTM LIN + SWITCH
R3	5322 102 34003	2X47K	20	0,1W	CARBON TANDEM POTM
R4	4822 101 20455	1K	20	0,1W	CARBON POTM LIN
R5	4822 101 20455	1K	20	0,1W	CARBON POTM LIN
R6	4822 101 20289	22K	20	0,1W	CARBON POTM LIN
R7	4822 101 20289	22K	20	0,1W	CARBON POTM LIN
R8	5322 101 44006	22K	20	0,25W	CARBON POTM LIN + SWITCH
R9	5322 101 24032	470K4K7		0,25W	CARBON POTM LIN
R10	4822 101 20305	470K	20	0,25W	CARBON POTM LIN
R11	5322 101 24045	1K	20	CP23	CARBON POTM LIN
R12	5322 101 24045	1K	20	CP23	CARBON POTM LIN
R26	4822 110 63072	47	5	CR25	CARBON
R27	5322 116 54212	900K	1	MR30	METAL FILM
R28	4822 110 63072	47	5	CR25	CARBON
R29	5322 116 54856	111K	1	MR30	METAL FILM
R32	5322 116 54209	992K	1	MR30	METAL FILM
R33		10,1K	1	MR30	CARBON TRIMMING POTM
R36	5322 116 54858	156	C,25	MR34C	METAL FILM
R37	5322 116 54273	437	C,25	MR34C	METAL FILM
R38	5322 116 50486	1,11K	C,25	MR34C	METAL FILM
R39	5322 116 50385	4,75K	C,25	MR34C	METAL FILM
R40	5322 116 50289	348	C,25	MR34C	METAL FILM
R41	5322 116 54274	898	C,25	MR34C	METAL FILM
R42	5322 116 54275	1,89K	C,25	MR34C	METAL FILM
R43	5322 116 54276	17,2K	C,25	MR34C	METAL FILM
R44	5322 116 50552	4,27K	C,25	MR34C	METAL FILM
R51	5322 116 54749	90,9K	1	MR30	METAL FILM
R52	5322 116 54408	909K	1	MR30	METAL FILM
R53	4822 110 63072	47	5	CR25	CARBON
R54	4822 110 63072	47	5	CR25	CARBON
R56	4822 110 63072	47	5	CR25	CARBON
R57	4822 110 63103	680	5	CR25	CARBON
R58	4822 110 63127	5,6K	5	CR25	CARBON
R59	4822 110 63072	47	5	CR25	CARBON
R60	4822 110 63129	6,8K	5	CR25	CARBON
R61	4822 110 63132	8,2K	5	CR25	CARBON
R62	5322 116 54277	4,93K	C,25	MR34C	METAL FILM
R63	4822 110 63094	330	5	CR25	CARBON
R64	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R65	4822 110 63056	12	5	CR25	CARBON
R66	4822 110 60077	75	5	CR25	CARBON
R67	4822 110 63132	8,2K	5	CR25	CARBON
R68	5322 116 34011	33	10	0,5W	NTC
R69	4822 110 63081	100	5	CR25	CARBON
R71	4822 110 63134	10K	5	CR25	CARBON
R72	4822 110 63134	10K	5	CR25	CARBON
R73	4822 110 63085	150	5	CR25	CARBON
R74	4822 110 60115	2K	5	CR25	CARBON
R75	4822 110 63121	3,3K	5	CR25	CARBON
R76	4822 110 63161	100K	5	CR25	CARBON
R77	4822 110 63072	47	5	CR25	CARBON
R78	4822 110 63116	2,2K	5	CR25	CARBON
R81	4822 110 53129	6,8K	5	CR37	CARBON
R82	4822 110 53129	6,8K	5	CR37	CARBON
R83	4822 110 63094	330	5	CR25	CARBON
R84	4822 110 53127	5,6K	5	CR37	CARBON
R85	4822 116 20063			VDR	VDR
R86	4822 110 63083	120	5	CR25	CARBON
R87	4822 110 53127	5,6K	5	CR37	CARBON
R88	4822 110 63127	5,6K	5	CR25	CARBON
R89	4822 110 63103	680	5	CR25	CARBON
R91	4822 110 63089	220	5	CR25	CARBON
R92	4822 110 63121	3,3K	5	CR25	CARBON
R93	4822 110 60115	2K	5	CR25	CARBON
R94	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R95	4822 110 63081	100	5	CR25	CARBON
R96	4822 110 60131	7,5K	5	CR25	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R97	5322 116 54855	5,36K	1	MR30	METAL FILM
R98	4822 110 63072	47	5	CR25	CARBON
R99	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R100	4822 110 63081	100	5	CR25	CARBON
R101	5322 116 54595	5,11K	1	MR25	METAL FILM
R102	5322 116 54255	17,4K	0,25	MR34C	METAL FILM
R103	4822 110 60099	510	5	CR25	CARBON
R104	4822 110 63107	1K	5	CR25	CARBON
R106	4822 110 53072	47	5	CR37	CARBON
R107	5322 116 54587	3,65K	1	MR25	METAL FILM
R108	4822 110 63096	390	5	CR25	CARBON
R109	5322 116 54587	3,65K	1	MR25	METAL FILM
R111	5322 101 14058	470	20	0,1W	CARBON TRIMMING POTM
R112	4822 110 63092	270	5	CR25	CARBON
R113	*		5	CR25	CARBON
R114	4822 110 63152	47K	5	CR25	CARBON
R116	4822 110 63107	1K	5	CR25	CARBON
R117	4822 110 63152	47K	5	CR25	CARBON
R118	4822 110 63096	390	5	CR25	CARBON
R119	4822 110 63107	1K	5	CR25	CARBON
R121	4822 110 63134	10K	5	CR25	CARBON
R122	4822 110 42214	10M	5	VR37	CARBON
R123	4822 110 42207	5,6M	5	VR37	CARBON
R124	4822 110 63132	8,2K	5	CR25	CARBON
R125	4822 110 63116	2,2K	5	CR25	CARBON
R126	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R127	4822 110 42214	10M	5	VR37	CARBON
R128	5322 116 54408	909K	1	MR30	METAL FILM
R129	4822 110 42214	10M	5	VR37	CARBON
R130	4822 110 63141	10K	5	CR25	CARBON
R131	4822 110 60179	510K	5	CR25	CARBON
R132	4822 110 53127	5,6K	5	CR37	CARBON
R133	4822 110 53127	5,6K	5	CR37	CARBON
R134	4822 110 63083	120	5	CR25	CARBON
R135	4822 116 20063			VDR	VDR
R136	4822 110 63094	330	5	CR25	CARBON
R137	4822 110 53129	6,8K	5	CR37	CARBON
R138	4822 110 53129	6,8K	5	CR37	CARBON
R142	4822 110 63054	10	5	CR25	CARBON
R143	4822 110 63043	3,9	5	CR25	CARBON
R144	4822 110 63103	680	5	CR25	CARBON
R145	4822 110 63072	47	5	CR25	CARBON
R146	4822 110 63103	680	5	CR25	CARBON
R147	4822 110 63103	680	5	CR25	CARBON
R226	4822 110 63072	47	5	CR25	CARBON
R227	5322 116 54212	900K	1	MR30	METAL FILM
R228	4822 110 63072	47	5	CR25	CARBON
R229		111K	1	MR30	CARBON TRIMMING POTM
R232	5322 116 54209	992K	1	MR30	METAL FILM
R233	5322 116 54857	10,1K	1	MR30	METAL FILM
R236		156	0,25	MR34C	CARBON TRIMMING POTM
R237	5322 116 54273	437	0,25	MR34C	METAL FILM
R238	5322 116 50486	1,11K	0,25	MR34C	METAL FILM
R239	5322 116 50385	4,75K	0,25	MR34C	METAL FILM
R240	5322 116 50289	348	0,25	MR34C	METAL FILM
R241	5322 116 54274	898	0,25	MR34C	METAL FILM
R242	5322 116 54275	1,89K	0,25	MR34C	METAL FILM
R243	5322 116 54276	17,2K	0,25	MR34C	METAL FILM
R244	5322 116 50552	4,27K	0,25	MR34C	METAL FILM
R251	5322 116 54749	90,9K	1	MR30	METAL FILM
R252	5322 116 54408	909K	1	MR30	METAL FILM
R253	4822 110 63072	47	5	CR25	CARBON
R254	4822 110 63072	47	5	CR25	CARBON
R256	4822 110 63072	47	5	CR25	CARBON
R257	4822 110 63103	680	5	CR25	CARBON
R258	4822 110 63127	5,6K	5	CR25	CARBON
R259	4822 110 63072	47	5	CR25	CARBON
R261	4822 110 63132	8,2K	5	CR25	CARBON
R262	5322 116 54277	4,93K	0,25	MR34C	METAL FILM
R263	4822 110 63094	330	5	CR25	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R264	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R265	4822 110 63056	12	5	CR25	CARBON
R266	4822 110 60077	75	5	CR25	CARBON
R267	4822 110 63132	8,2K	5	CR25	CARBON
R268	5322 116 34011	33	10	0,5W	NTC
R272	4822 110 63116	2,2K	5	CR25	CARBON
R276	4822 110 63161	100K	5	CR25	CARBON
R277	4822 110 63072	47	5	CR25	CARBON
R278	4822 110 60115	2K	5	CR25	CARBON
R280	4822 110 63085	150	5	CR25	CARBON
R281	4822 110 53129	6,8K	5	CR37	CARBON
R282	4822 110 53129	6,8K	5	CR37	CARBON
R283	4822 110 60093	300	5	CR25	CARBON
R284	4822 110 53127	5,6K	5	CR37	CARBON
R285	4822 116 20063			VDR	VDR
R286	4822 110 63083	120	5	CR25	CARBON
R287	4822 110 53127	5,6K	5	CR37	CARBON
R288	4822 110 63127	5,6K	5	CR25	CARBON
R289	4822 110 63103	680	5	CR25	CARBON
R291	4822 110 63089	220	5	CR25	CARBON
R292	4822 110 63121	3,3K	5	CR25	CARBON
R293	4822 110 60115	2K	5	CR25	CARBON
R294	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R295	4822 110 63069	39	5	CR25	CARBON
R296	4822 110 60131	7,5K	5	CR25	CARBON
R297		5,36K	1	MR30	CARBON TRIMMING POTM
R298	4822 110 63072	47	5	CR25	CARBON
R299	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R300	4822 110 63081	100	5	CR25	CARBON
R301	5322 116 54595	5,11K	1	MR25	METAL FILM
R302	5322 116 54255	17,4K	0,25	MR34C	METAL FILM
R303	4822 110 60099	510	5	CR25	CARBON
R306	4822 110 63072	47	5	CR25	CARBON
R307	5322 116 54587	3,65K	1	MR25	METAL FILM
R308	4822 110 63096	390	5	CR25	CARBON
R309	5322 116 54587	3,65K	1	MR25	METAL FILM
R311	5322 101 14058	470	20	0,1W	CARBON TRIMMING POTM
R312	4822 110 63092	270	5	CR25	CARBON
R313	*		5	CR25	CARBON
R314	4822 110 63152	47K	5	CR25	CARBON
R316	4822 110 63107	1K	5	CR25	CARBON
R317	4822 110 63152	47K	5	CR25	CARBON
R318	4822 110 63096	390	5	CR25	CARBON
R319	4822 110 63107	1K	5	CR25	CARBON
R321	4822 110 63134	10K	5	CR25	CARBON
R322	4822 110 42214	10M	5	VR37	CARBON
R323	4822 110 42207	5,6M	5	VR37	CARBON
R324	4822 110 63132	8,2K	5	CR25	CARBON
R326	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R327	4822 110 42214	10M	5	VR37	CARBON
R328	5322 116 54408	909K	1	MR30	METAL FILM
R329	4822 110 42214	10M	5	VR37	CARBON
R331	4822 110 60179	510K	5	CR37	CARBON
R332	4822 110 53127	5,6K	5	CR37	CARBON
R333	4822 110 53127	5,6K	5	CR37	CARBON
R334	4822 110 63083	120	5	CR25	CARBON
R335	4822 116 20063			VDR	VDR
R336	4822 110 60093	300	5	CR25	CARBON
R337	4822 110 53129	6,8K	5	CR37	CARBON
R338	4822 110 53129	6,8K	5	CR37	CARBON
R339	4822 110 63043	3,9	5	CR25	CARBON
R341	4822 110 63081	100	5	CR25	CARBON
R342	4822 110 63054	10	5	CR25	CARBON
R345	4822 110 63072	47	5	CR25	CARBON
R346	4822 110 63103	680	5	CR25	CARBON
R400	4822 110 63196	2,2M	10	CR25	CARBON
R401	5322 116 50725	91K	5	CR37	METAL FILM
R402	4822 110 63134	10K	5	CR25	CARBON
R403	5322 116 54595	5,11K	1	MR25	METAL FILM
R404	5322 116 54603	6,49K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R405	4822 110 63072	47	5	CR25	CARBON
R406	4822 110 63098	470	5	CR25	CARBON
R407	4822 110 63098	470	5	CR25	CARBON
R408	4822 110 63132	8,2K	5	CR25	CARBON
R409	4822 110 60124	4,3K	5	CR25	CARBON
R410	4822 110 63134	10K	5	CR25	CARBON
R411	4822 110 63125	4,7K	5	CR25	CARBON
R412	4822 110 60117	2,4K	5	CR25	CARBON
R413	4822 110 60108	1,1K	5	CR25	CARBON
R414	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R415	4822 110 63116	2,2K	5	CR25	CARBON
R416	4822 110 63098	470	5	CR25	CARBON
R418	4822 110 60142	20K	5	CR25	CARBON
R419	4822 110 63072	47	5	CR25	CARBON
R420	4822 110 63072	47	5	CR25	CARBON
R421	4822 110 63081	100	5	CR25	CARBON
R422	4822 110 63081	100	5	CR25	CARBON
R423	4822 110 63109	1,2K	5	CR25	CARBON
R424	4822 100 10029	2,2K	20	0,1W	CARBON TRIMMING POTM
R426	4822 110 63107	820	5	CR25	CARBON
R427	4822 110 63072	47	5	CR25	CARBON
R428	4822 110 63145	27K	5	CR25	CARBON
R429	4822 110 63107	1K	5	CR25	CARBON
R430	4822 110 63169	220K	5	CR25	CARBON
R431	4822 110 63072	47	5	CR25	CARBON
R432	4822 110 63152	47K	5	CR25	CARBON
R433	4822 110 63143	22K	5	CR25	CARBON
R434	4822 110 63125	4,7K	5	CR25	CARBON
R436	4822 110 63143	22K	5	CR25	CARBON
R437	4822 110 63109	1,2K	5	CR25	CARBON
R438	4822 110 63118	2,7K	5	CR25	CARBON
R439	4822 110 63118	2,7K	5	CR25	CARBON
R440	4822 110 63072	47	5	CR25	CARBON
R441	4822 110 63152	47K	5	CR25	CARBON
R442	4822 110 63194	1,8M	10	CR25	CARBON
R443	4822 110 63072	47	5	CR15	CARBON
R444	4822 110 63161	100K	5	CR25	CARBON
R446	4822 110 60151	43K	5	CR25	CARBON
R447	4822 110 63114	1,8K	5	CR25	CARBON
R448	4822 110 60097	430	5	CR25	CARBON
R449	4822 110 63072	47	5	CR25	CARBON
R501	5322 116 54426	121	1	MR25	METAL FILM
R502	5322 116 54005	3,32K	1	MR25	METAL FILM
R503	4822 110 60086	100	5	CR25	CARBON
R504	4822 110 63072	47	5	CR25	CARBON
R506	5322 116 54557	1,21K	1	MR25	METAL FILM
R507	5322 116 54619	10K	1	MR25	METAL FILM
R508	4822 110 60091	240	5	CR25	CARBON
R509	4822 110 63103	680	5	CR25	CARBON
R511	4822 110 60128	6,2K	5	CR25	CARBON
R512	4822 110 63109	1,2K	5	CR25	CARBON
R513	4822 110 63121	3,3K	5	CR25	CARBON
R514	4822 110 63107	1K	5	CR25	CARBON
R516	4822 110 60119	3K	5	CR25	CARBON
R517	4822 110 60137	13K	5	CR25	CARBON
R518	4822 110 63129	6,8K	5	CR25	CARBON
R519	4822 110 63156	68K	5	CR25	CARBON
R521	4822 110 63116	2,2K	5	CR25	CARBON
R522	4822 110 63081	100	5	CR25	CARBON
R524	4822 110 63116	2,2K	5	CR25	CARBON
R526	4822 110 63098	470	5	CR25	CARBON
R527	4822 110 63134	10K	5	CR25	CARBON
R528	4822 110 60157	75K	5	CR25	CARBON
R529	4822 110 63094	330	5	CR25	CARBON
R530	4822 110 63072	47	5	CR25	CARBON
R531	4822 110 63103	680	5	CR25	CARBON
R532	4822 116 30018	1,3K	20	1W	NTC
R533	4822 110 63121	3,3K	5	CR25	CARBON
R534	4822 100 10029	2,2K	20	0,1W	CARBON TRIMMING POTM
R536	4822 110 60126	5,1K	5	CR25	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R537	4822 110 63132	8,2K	5	CR25	CARBON
R538	4822 110 60128	6,2K	5	CR25	CARBON
R539	4822 100 10051	22K	20	0,1W	CARBON TRIMMING POTM
R541	4822 110 63072	47	5	CR25	CARBON
R542	4822 110 63081	100	5	CR25	CARBON
R543	4822 110 63087	180	5	CR25	CARBON
R544	4822 110 63081	100	5	CR25	CARBON
R547	4822 110 63101	560	5	CR25	CARBON
R549	4822 110 63094	330	5	CR25	CARBON
R551	4822 110 63134	10K	5	CR25	CARBON
R552	4822 110 63127	5,6K	5	CR25	CARBON
R553	4822 100 10029	2,2K	20	0,1W	CARBON TRIMMING POTM
R554	4822 110 63136	12K	5	CR25	CARBON
R556	4822 110 63072	47	5	CR25	CARBON
R557	4822 110 63107	1K	5	CR25	CARBON
R558	4822 110 53107	1K	5	CR37	CARBON
R559	4822 110 63125	4,7K	5	CR25	CARBON
R561	4822 110 63063	22	5	CR25	CARBON
R562	4822 110 63063	22	5	CR25	CARBON
R563	4822 110 63063	22	5	CR25	CARBON
R565	4822 110 63107	1K	5	CR25	CARBON
R566	5322 116 54278	576K	1	MR30	METAL FILM
R567	5322 116 54729	226K	1	MR25	METAL FILM
R568	5322 116 54279	115K	1	MR25	METAL FILM
R569	5322 116 54676	56,2K	1	MR25	METAL FILM
R570	4822 110 63072	47	5	CR25	CARBON
R571	5322 116 50481	22,6K	1	MR25	METAL FILM
R572	5322 116 50668	11,3K	1	MR25	METAL FILM
R573	5322 116 54011	5,62K	1	MR25	METAL FILM
R574	5322 116 54574	2,21K	1	MR25	METAL FILM
R576	5322 116 50842	1,1K	1	MR25	METAL FILM
R601	4822 100 10037	1K	20	0,1W	CARBON TRIMMING POTM
R602	4822 110 63112	1,5K	5	CR25	CARBON
R603	4822 110 63081	100	5	CR25	CARBON
R604	4822 110 60119	3K	5	CR25	CARBON
R606	4822 110 63132	8,2K	5	CR25	CARBON
R607	4822 110 63136	12K	5	CR25	CARBON
R609	4822 110 63156	68K	5	CR25	CARBON
R610	4822 110 63116	2,2K	5	CR25	CARBON
R611	4822 110 63072	47	5	CR25	CARBON
R612	4822 110 60102	620	5	CR25	CARBON
R613	4822 110 63127	5,6K	5	CR25	CARBON
R614	4822 110 63114	1,8K	5	CR25	CARBON
R615	4822 110 60119	3K	5	CR25	CARBON
R616	4822 110 63072	47	5	CR25	CARBON
R617	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R618	4822 100 10035	10K	20	0,1W	CARBON TRIMMING POTM
R619	4822 110 63156	68K	5	CR25	CARBON
R621	4822 110 60119	3K	5	CR25	CARBON
R622	4822 110 63129	6,8K	5	CR25	CARBON
R623	4822 110 60119	3K	5	CR25	CARBON
R624	4822 110 63114	1,8K	5	CR25	CARBON
R626	4822 110 63134	10K	5	CR25	CARBON
R627	4822 110 53152	47K	5	CR27	CARBON
R628	4822 110 53152	47K	5	CR37	CARBON
R629	4822 116 20063			VDR	VDR
R631	4822 110 63107	820	5	CR25	CARBON
R632	4822 110 63063	22	5	CR25	CARBON
R633	4822 110 53152	47K	5	CR37	CARBON
R634	4822 116 20063			VDR	VDR
R636	4822 110 63107	820	5	CR25	CARBON
R637	4822 110 53152	47K	5	CR37	CARBON
R638	4822 110 63072	47	5	CR25	CARBON
R639	4822 110 63072	47	5	CR25	CARBON
R701	4822 110 63132	8,2K	5	CR25	CARBON
R704	4822 110 63072	47	5	CR25	CARBON
R705	4822 110 63072	47	5	CR25	CARBON
R706	4822 110 63123	3,9K	5	CR25	CARBON
R707	4822 110 63098	470	5	CR25	CARBON
R708	4822 110 63134	10K	5	CR25	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R709	4822 110 63156	68K	5	CR25	CARBON
R710	4822 110 63107	1K	5	CR25	CARBON
R711	4822 100 10029	2,2K	20	0,1W	CARBON TRIMMING POTM
R712	4822 110 63112	1,5K	5	CR25	CARBON
R713	4822 110 63187	1M	5	CR25	CARBON
R714	4822 110 63187	1M	5	CR25	CARBON
R715	4822 110 63081	100	5	CR25	CARBON
R716	4822 110 63129	6,8K	5	CR25	CARBON
R717	4822 110 63147	33K	5	CR25	CARBON
R718	4822 110 63161	100K	5	CR25	CARBON
R719	4822 110 63156	68K	5	CR25	CARBON
R720	4822 110 63158	82K	5	CR25	CARBON
R721	4822 116 20063			VDR	VDR
R722	4822 110 63094	330	5	CR25	CARBON
R750	4822 110 63116	2,2K	5	CR25	CARBON
R751	4822 110 63123	3,9K	5	CR25	CARBON
R752	4822 110 63114	1,8K	5	CR25	CARBON
R753	4822 110 63132	8,2K	5	CR25	CARBON
R754	4822 110 63185	820K	5	CR25	CARBON
R756	4822 110 63101	560	5	CR25	CARBON
R757	4822 110 63123	3,9K	5	CR25	CARBON
R758	4822 110 63092	270	5	CR25	CARBON
R759	5322 116 54623	11K	1	MR25	METAL FILM
R761	4822 100 10037	1K	20	0,1W	CARBON TRIMMING POTM
R762	5322 116 50842	1,1K	1	MR25	METAL FILM
R763	4822 110 63072	47	5	CR25	CARBON
R764	4822 110 63072	47	5	CR25	CARBON
R800	4822 110 60175	360K	5	CR25	CARBON
R801	4822 100 10035	10K	20	0,1W	CARBON TRIMMING POTM
R802	4822 100 10107	470K	20	0,1W	CARBON TRIMMING POTM
R803	4822 110 20192	1,5M	10	CR68	CARBON
R804	*		1	MR30	METAL FILM
R805	4822 110 60117	2,4K	5	CR25	CARBON
R806	4822 110 63178	470K	5	CR25	CARBON
R807	4822 110 42194	1,8M	10	CR68	CARBON
R808	4822 110 23152	47K	5	CR68	CARBON
R809	4822 100 10107	470K	20	0,1W	CARBON TRIMMING POTM
R810	5322 116 54195	825K	1	MR30	METAL FILM
R811	4822 110 63161	100K	5	CR25	CARBON
R812	4822 100 10107	470K	20	0,1W	CARBON TRIMMING POTM
R813		1,5K	10	1W	CARBON TRIMMING POTM
R814	4822 110 63125	4,7K	5	CR25	CARBON
R815	4822 110 63027	1	5	CR25	CARBON
R816	4822 110 53112	1,5	5	CR37	CARBON
R817	4822 110 63143	22K	5	CR25	CARBON
R818	4822 110 63096	390	5	CR25	CARBON
R819	4822 110 63121	3,3K	5	CR25	CARBON
R820	4822 110 63101	560	5	CR25	CARBON
R821	4822 110 63152	47K	5	CR25	CARBON
R822	4822 110 63107	820	5	CR25	CARBON
R823	4822 100 10038	470	20	0,1W	CARBON TRIMMING POTM
R824	4822 110 63107	820	5	CR25	CARBON
R825	4822 110 63098	470	5	CR25	CARBON
R826	4822 110 63114	1,8K	5	CR25	CARBON
R827	4822 110 63054	10	5	CR25	CARBON
R828		8,2M	5	1W	CARBON TRIMMING POTM
R829	4822 110 60144	24K	5	CR25	CARBON
R830	4822 110 63134	10K	5	CR25	CARBON
R831	4822 110 63098	470	5	CR25	CARBON
R832	4822 110 60115	2K	5	CR25	CARBON
R901	4822 110 63187	1M	5	CR25	CARBON
R902	4822 110 63107	820	5	CR25	CARBON
R903	5322 116 54519	402	1	MR25	METAL FILM
R904	5322 116 50555	1,27K	1	MR25	METAL FILM
R906	4822 110 63072	47	5	CR25	CARBON
R907	*		5	CR25	CARBON
R908	4822 110 63107	820	5	CR25	CARBON
R909	4822 110 63098	470	5	CR25	CARBON
R911	5322 116 54541	825	1	MR25	METAL FILM
R912	4822 110 60122	3,6K	5	CR25	CARBON

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
R913	4822 110 60104	750	5	CR25	CARBON
R914	4822 110 60137	13K	5	CR25	CARBON
R916	5322 116 54484	140	1	MR25	METAL FILM
R917	5322 116 54484	140	1	MR25	METAL FILM
R918	5322 116 54531	634	1	MR25	METAL FILM
R919	4822 110 63072	47	5	CR25	CARBON
R921	4822 110 63123	3,9K	5	CR25	CARBON
R922	4822 110 63109	1,2K	5	CR25	CARBON
R923	5322 116 54585	3,48K	1	MR25	METAL FILM
R924	5322 116 50842	1,1K	1	MR25	METAL FILM
R1001	4822 110 63187	1M	5	CR25	CARBON
R1002	4822 110 63107	820	5	CR25	CARBON
R1003	5322 116 54519	402	1	MR25	METAL FILM
R1004	5322 116 50555	1,27K	1	MR25	METAL FILM
R1006	4822 110 63072	47	5	CR25	CARBON
R1007	*		5	CR25	CARBON
R1008	4822 110 63107	820	5	CR25	CARBON
R1009	4822 110 63098	470	5	CR25	CARBON
R1011	5322 116 54541	825	1	MR25	METAL FILM
R1012	4822 110 60122	3,6K	5	CR25	CARBON
R1013	4822 110 60104	750	5	CR25	CARBON
R1014	4822 110 60137	13K	5	CR25	CARBON
R1016	5322 116 54484	140	1	MR25	METAL FILM
R1017	5322 116 54484	140	1	MR25	METAL FILM
R1018	5322 116 54531	634	1	MR25	METAL FILM
R1019	4822 110 63072	47	5	CR25	CARBON
R1021	4822 110 63123	3,9K	5	CR25	CARBON
R1022	4822 110 63109	1,2K	5	CR25	CARBON
R1023	5322 116 54585	3,48K	1	MR25	METAL FILM
R1024	5322 116 50842	1,1K	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION

3.6.2.6. Transistors

TS51	5322 130 40408	BFW11
TS52	5322 130 44195	BF494
TS53	4822 130 40973	BC557
TS54	5322 130 44154	BF199
TS56	4822 130 40965	BC547
TS57	5322 130 44154	BF199
TS58	5322 130 44154	BF199
TS59	5322 130 44154	BF199
TS61	5322 130 44195	BF494
TS62	5322 130 40408	BFW11
TS63	5322 130 40373	BCY71
TS64	5322 130 40324	BCY70
TS66	4822 130 40964	BC549
TS67	4822 130 40964	BC549
TS68	5322 130 44154	BF199
TS69	5322 130 44154	BF199
TS71	5322 130 40144	BC109C
TS72	5322 130 40144	BC109C
TS73	5322 130 44154	BF199
TS74	5322 130 44154	BF199
TS75	4822 130 40963	BC559
TS76	5322 130 44154	BF199
TS251	5322 130 40408	BFW11
TS252	5322 130 44195	BF494
TS253	4822 130 40973	BC557
TS254	5322 130 44154	BF199
TS257	5322 130 44154	BF199
TS258	5322 130 44154	BF199
TS259	5322 130 44154	BF199
TS261	5322 130 44195	BF494
TS262	5322 130 40408	BFW11
TS263	5322 130 40373	BCY71
TS264	5322 130 40324	BCY70

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
TS266	4822 130 40964	BC549
TS267	4822 130 40964	BC549
TS268	5322 130 44154	BF199
TS269	5322 130 44154	BF199
TS271	5322 130 40144	BC109C
TS272	5322 130 40144	BC109C
TS273	5322 130 44154	BF199
TS274	5322 130 44154	BF199
TS276	5322 130 44154	BF199
TS400	4822 130 40963	BC559
TS401	4822 130 40963	BC559
TS402	5322 130 44195	BF494
TS403	5322 130 44216	BC549C
TS404	5322 130 44216	BC549C
TS406	4822 130 40964	BC549
TS407	4822 130 40965	BC547
TS501	5322 130 44195	BF494
TS502	5322 130 44195	BF494
TS503	5322 130 44195	BF494
TS504	5322 130 44195	BF494
TS506	4822 130 40973	BC557
TS508	4822 130 40965	BC547
TS509	5322 130 40417	BSX20
TS511	4822 130 40963	BC559
TS512	4822 130 40964	BC549
TS513	4822 130 40964	BC549
TS516	4822 130 40965	BC547
TS602	5322 130 44195	BF494
TS603	5322 130 44195	BF494
TS604	5322 130 44195	BF494
TS606	4822 130 40965	BC547
TS607	4822 130 40908	BF336
TS608	4822 130 40908	BF336
TS609	4822 130 40908	BF336
TS611	4822 130 40908	BF336
TS702	4822 130 40973	BC557
TS703	5322 130 40321	BSX21
TS704	5322 130 40308	BF115
TS706	5322 130 40308	BF115
TS750	5322 130 44195	BF494
TS751	5322 130 44195	BF494
TS800	5322 130 44247	BSS68
TS801	4822 130 40908	BF336
TS802	5322 130 40294	BFY50
TS803	4822 130 40973	BC557
TS804	4822 130 40965	BC547
TS806	5322 130 44157	BD183
TS807	5322 130 44157	BD183
TS901	5322 130 44216	BC549C
TS902	5322 130 44195	BF494
TS903	5322 130 44195	BF494
TS904	4822 130 40964	BC549
TS906	5322 130 44216	BC549C
TS1001	5322 130 44216	BC549C
TS1002	5322 130 44195	BF494
TS1003	5322 130 44195	BF494
TS1004	4822 130 40964	BC549
TS1006	5322 130 44216	BC549C

*Choice components

When adjusting the instrument, the values of the choice components should be selected between the following limit values.
The choice components can be recognized in the diagram by the hatching over the components and the lacking of a value indication.

R113 47...4,7 k R313 47...4,7 k R804 383 k...1 M R907 270 Ω...390 Ω
R1007 270 Ω...390 Ω

3.6.3. PARTS LIST OF PROBE SETS

3.6.3.1. Parts of attenuator probe sets PM 9326 and PM 9327 (Fig. 3.24)

Item	*Qty*	*Ordering number*	*Description*
1	1	5322 320 10042	Probe cable 2 m for PM 9327
1	1	5322 321 20087	Probe cable 1.15 m for PM 9326
2	1	5322 321 20096	Earth lead 15 cm
3	1	5322 321 20134	Earth lead 30 cm
4	1	5322 266 20015	Measuring probe 1:1 (black)
5	1	5322 268 10029	Test pin
6	1	5322 268 10039	Test hook
7	1	5322 210 70044	Attenuator probe 1:10 (grey)
8	1	5322 264 20016	Test clip
	1	5322 111 20155	Resistor

3.6.3.2. Parts of attenuator probe sets PM 9336 and PM 9336L (Fig. 3.26.)

Item	*Qty*	*Ordering code*	*Description*
1	1	5322 320 14004	Cable assembly PM 9336 (1,5 m)
1	1	5322 320 14013	Cable assembly PM 9336L (2,5 m)
2	1	5322 255 44026	Soldering terminal
3	1	5322 264 20024	Test hook
4	1	5322 264 20028	Test hook sleeve
5	1	5322 532 60535	Protective cap
6	1	5322 256 94034	Probe holder
7	1	5322 268 14017	Probe tip
8	1	5322 321 20223	Earthing cord
9	1	5322 600 34002	Box

3.6.3.3. Parts of probe set PM 9335 (Fig. 3.28.)

Item	*Qty*	*Ordering number*	*Description*
1	1	5322 264 20024	Test-hook
2	1	5322 264 20028	Test-hook sleeve
3	1	5322 268 14017	Probe tip
4	1	5322 532 60535	Protective cap
5	1	5322 321 20223	Earth lead
6	1	5322 265 94034	Probe holder
7	1	5322 320 14005	Probe assembly
	1	5322 600 34002	Box

3.6.3.4. Parts of 2 kV probe set PM 9358 (Fig. 3.29.)

Item	*Qty*	*Order number*	*Description*
1	1	5322 320 14004	Cable assembly
2	1	5322 255 44026	Soldering terminal
3	1	5322 264 24008	Test hook
4	1	5322 264 24009	Test hook sleeve
5	1	5322 462 74001	Protective cap
6	1	5322 462 54075	Insulating cap
7	1	5322 256 94034	Probe holder
8	1	5322 264 24011	Test pin
9	1	5322 321 20223	Earthing cord
	1	5322 600 14004	Box

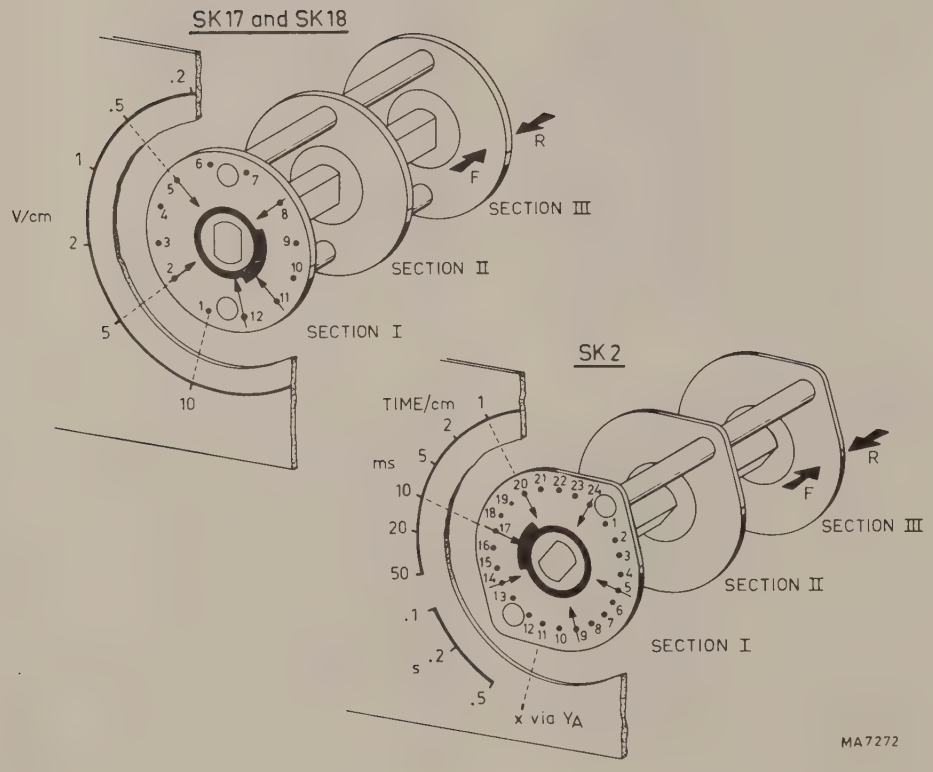


Fig. 3.38. Lay-out of the AMPL. and TIME/cm switches

QUALITY REPORTING

CODING SYSTEM FOR FAILURE DESCRIPTION

The following information is meant for Philips service workshops only and serves as a guide for exact reporting of service repairs and maintenance routines on the workshop charts.
For full details reference is made to Information G1 (Introduction) and Information Cd 689 (Specific information for Test and Measuring Instruments).

LOCATION

□□□
Unit number
e.g. 000A or 0001 (for unit A or 1; not 00UA or 00U1)

or: Type number of an accessory (only if delivered with the equipment)
e.g. 9051 or 9532 (for PM 9051 or PM 9532)

or: Unknown/Not applicable
0000

CATEGORY

□

0 Unknown, not applicable (fault not present, intermittent or disappeared)
1 Software error
2 Readjustment
3 Electrical repair (wiring, solder joint, etc.)
4 Mechanical repair (polishing, filing, remachining, etc.)
5 Replacement
6 Cleaning and/or lubrication
7 Operator error
8 Missing items (on pre-sale test)
9 Environmental requirements are not met

COMPONENT/SEQUENCE NUMBER

□□□□

Enter the identification as used in the circuit diagram, e.g.:

GR1003	Diode GR1003
TS0023	Transistor TS23
IC0101	Integrated circuit IC101
R0....	Resistor, potentiometer
C0....	Capacitor, variable capacitor
B0....	Tube, valve
LA....	Lamp
VL...	Fuse
SK....	Switch
BU....	Connector, socket, terminal
T0....	Transformer
L0....	Coil
X0....	Crystal
CB....	Circuit block
RE....	Relay
ME....	Meter, indicator
BA....	Battery
TR....	Chopper

Parts not identified in the circuit diagram:

990000	Unknown/Not applicable
990001	Cabinet or rack (text plate, emblem, grip, rail, graticule, etc.)
990002	Knob (incl. dial knob, cap, etc.)
990003	Probe (only if attached to instrument)
990004	Leads and associated plugs
990005	Holder (valve, transistor, fuse, board, etc.)
990006	Complete unit (p.w. board, h.t. unit, etc.)
990007	Accessory (only those without type number)
990008	Documentation (manual, supplement, etc.)
990009	Foreign object
990099	Miscellaneous

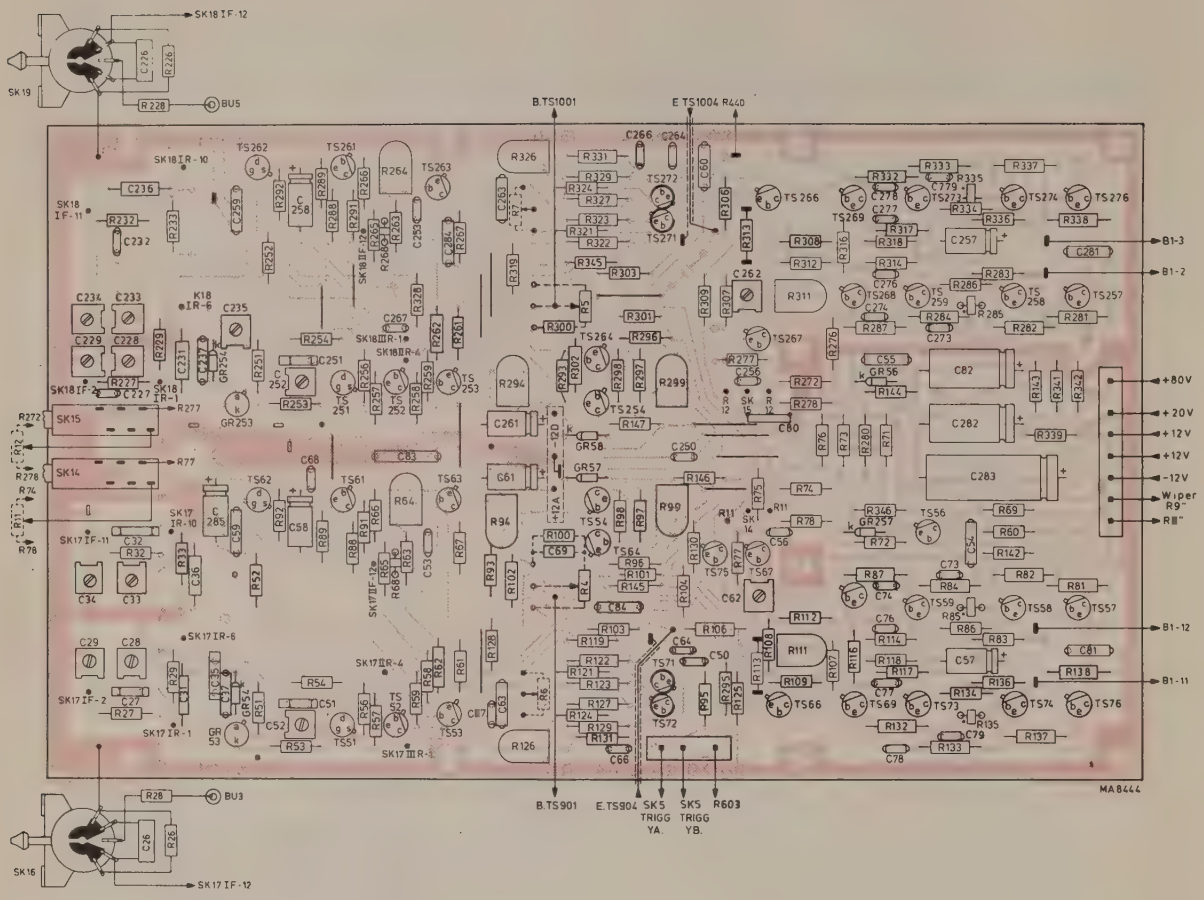


Fig. 3.39. A and B vertical amplifier unit

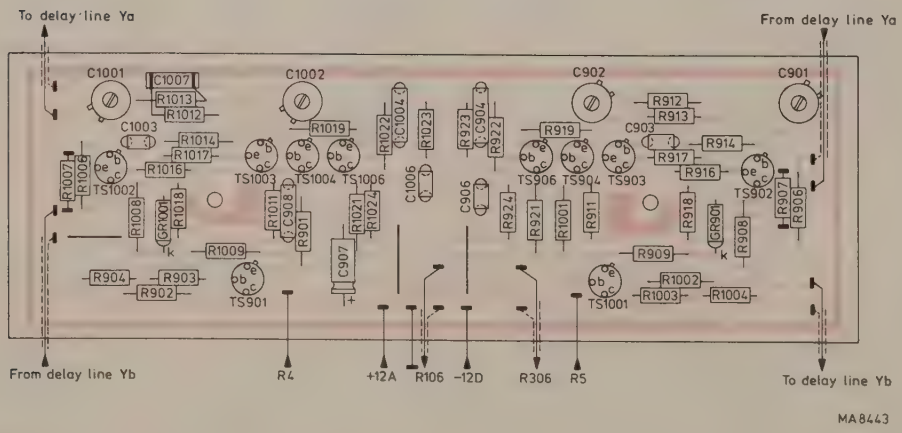


Fig. 3.40. Delay line unit

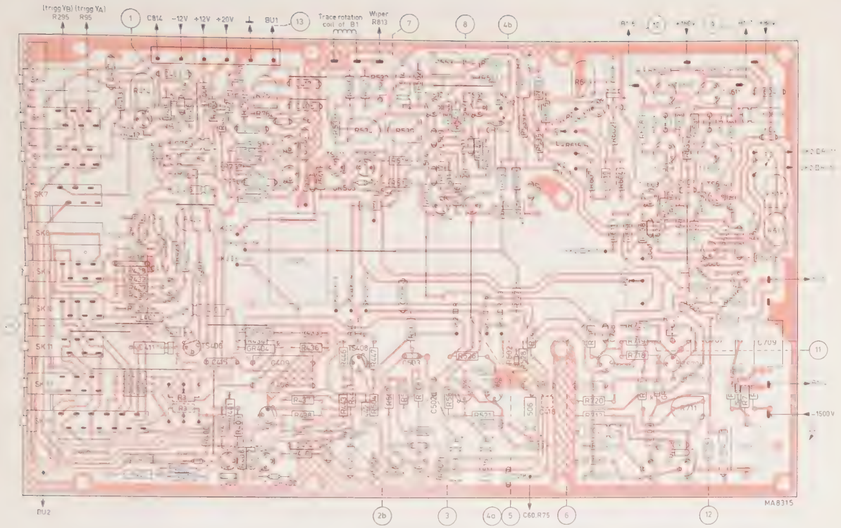


Fig. 3.41. Time-base unit

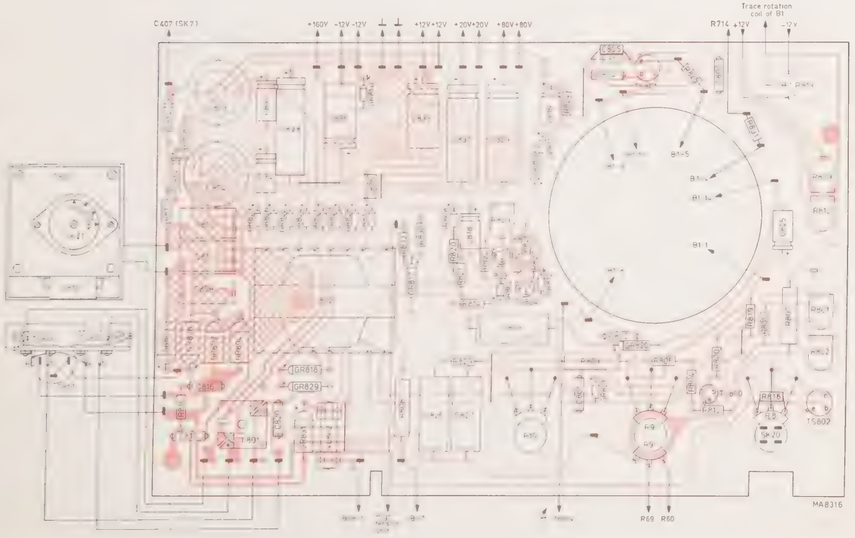
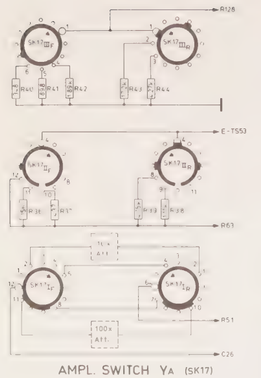
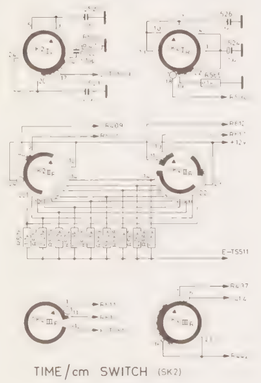
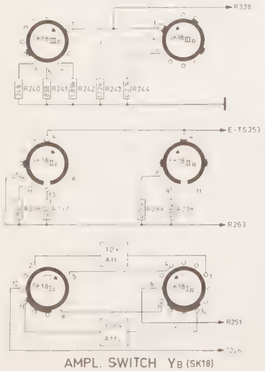
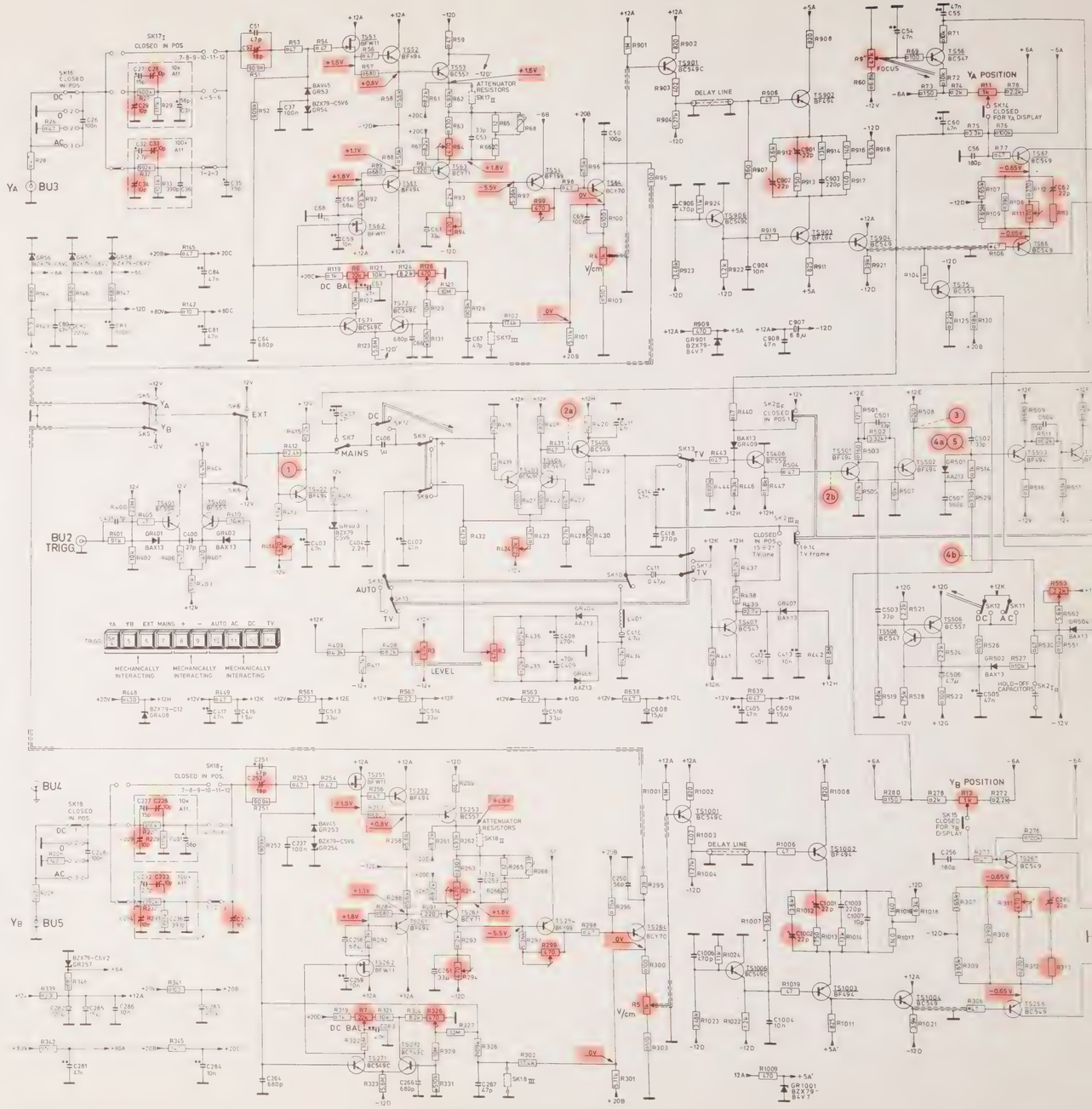


Fig. 3.42. Power supply unit









LOCATION OF COMPONENTS

Items 25....399 on A and B vertical amplifier unit
Items 400....799 on Time-base unit
Items 800....899 on Power supply unit
Items 900....1100 on Delay line unit

TABEL T801

COIL	S1a	S1b	S1'	S1'a	S1'b	S1'c	S2	S3
CONNECTIONS	1-2	2-3	4-5	6-7	7-8	8-9	12-13	10-11
TURNS	440	±5	75	440	±5	75	105	105
P.M.S VOLTAGE	100V	10V	17V	100V	10V	17V	24V	24V
R20°C ±10%	30Ω	3Ω	5Ω	30Ω	3Ω	5Ω	1Ω	1Ω
Ø	0.2	0.2	0.2	0.2	0.2	0.2	0.56	0.56

1 — Y=0.2V/cm X=0.2ms/cm
Trigger signal (sine-wave) at collector of transistor TS402 PM3232 sine-wave signal 6 Vp.p. 2 kHz on YA (1V/cm) Trigg via YA in pos. + and auto. potmeter LEVEL in the middle position

2a — Y=2V/cm X=0.5ms/cm
a) Output signal at the long-tailed pair circuit (in this case for triggering on the positive slope of the signal)

2b
b) Trigger signal at the input of the trigger-pulse shaper

3 — Y=2V/cm X=0.5ms/cm
Trigger signal at the output of the trigger-pulse shaper

4a — Y=0.5V/cm X=0.5ms/cm
a) Trigger pulses at the input of the sweep-gating multivibrator

4b
b) Hold-off signal

5 — Y=0.5V/cm X=0.5ms/cm
Signal at the input of the sweep-gating multivibrator in the absence of a trigger input signal

6 — Y=2V/cm X=0.5ms/cm
Driver pulses for sawtooth generator and blanking circuits

7 — Y=1V/cm X=0.5ms/cm
Sawtooth signal

8 — Y=1V/cm X=0.5ms/cm
Sawtooth signal at the output of cascade emitter followers circuit

9 — Y=20V/cm X=0.5ms/cm
Time-base deflection voltage

10 — Y=20V/cm X=0.5ms/cm
Time-base deflection voltage

11 — Y=10V/cm X=0.5ms/cm
Blanking pulses

12 — Y=10V/cm X=0.5ms/cm
Modulated signal at blanking pulses and oscillator signal

13 — Y=0.1V/cm X=0.2ms/cm
Calibration signal

MA 8308

Fig. 3.43. Circuit diagram of the complete oscilloscope PM 3233 (small)

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